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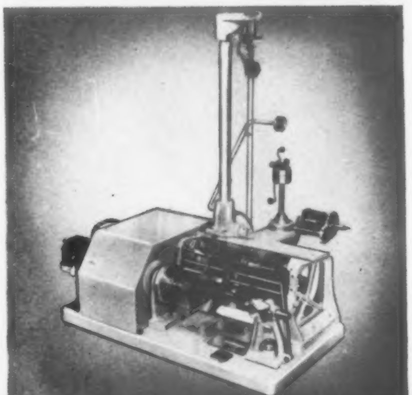

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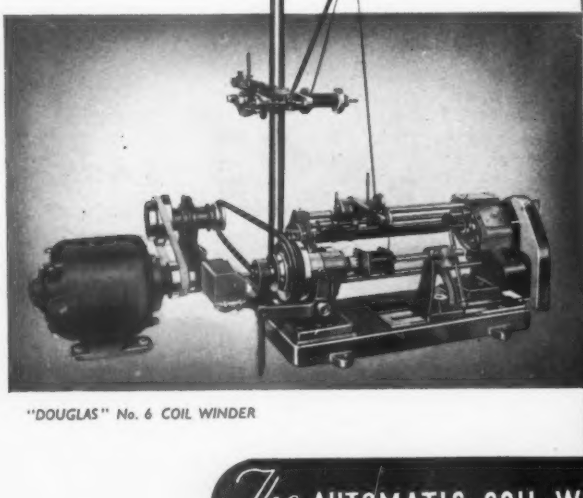

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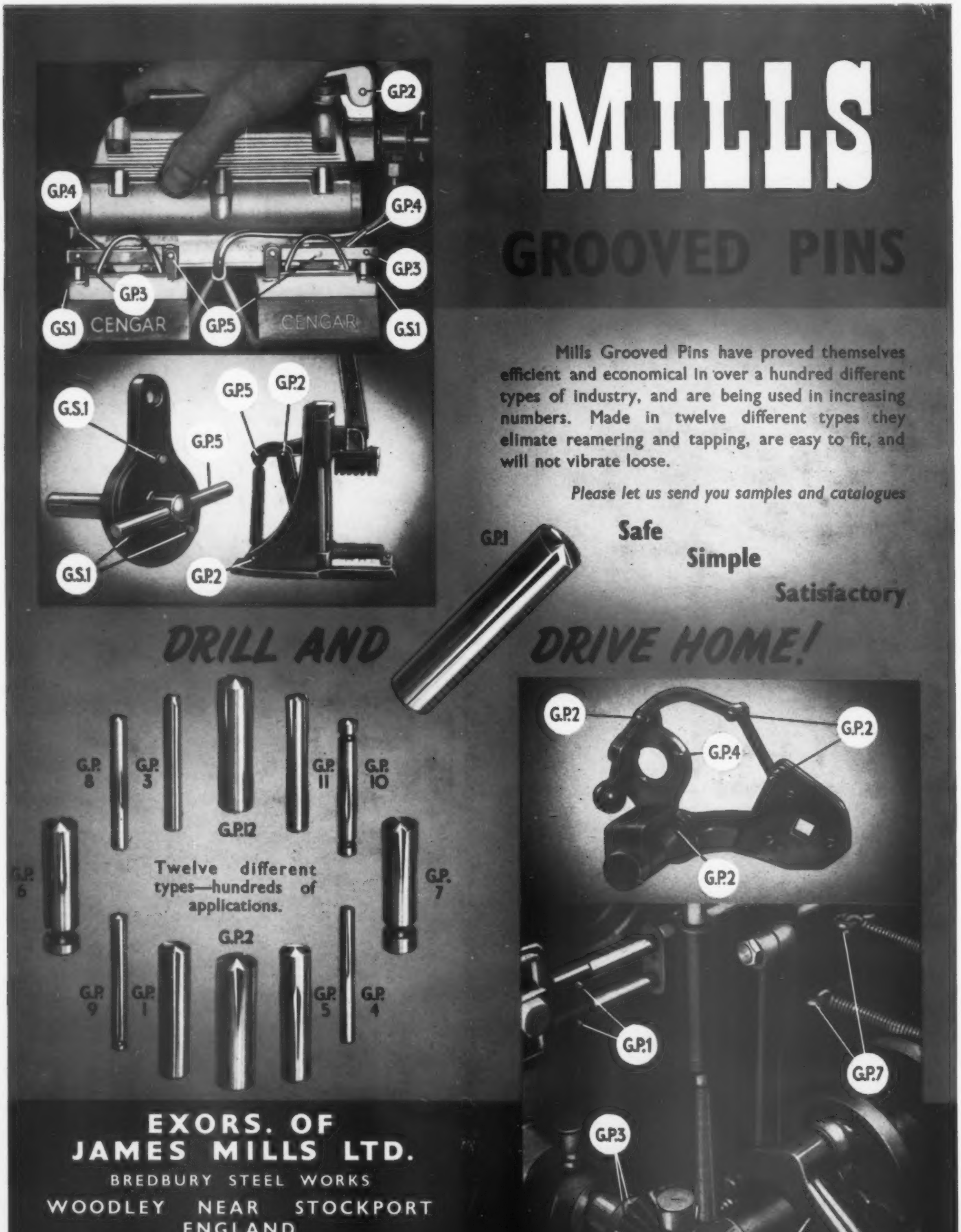
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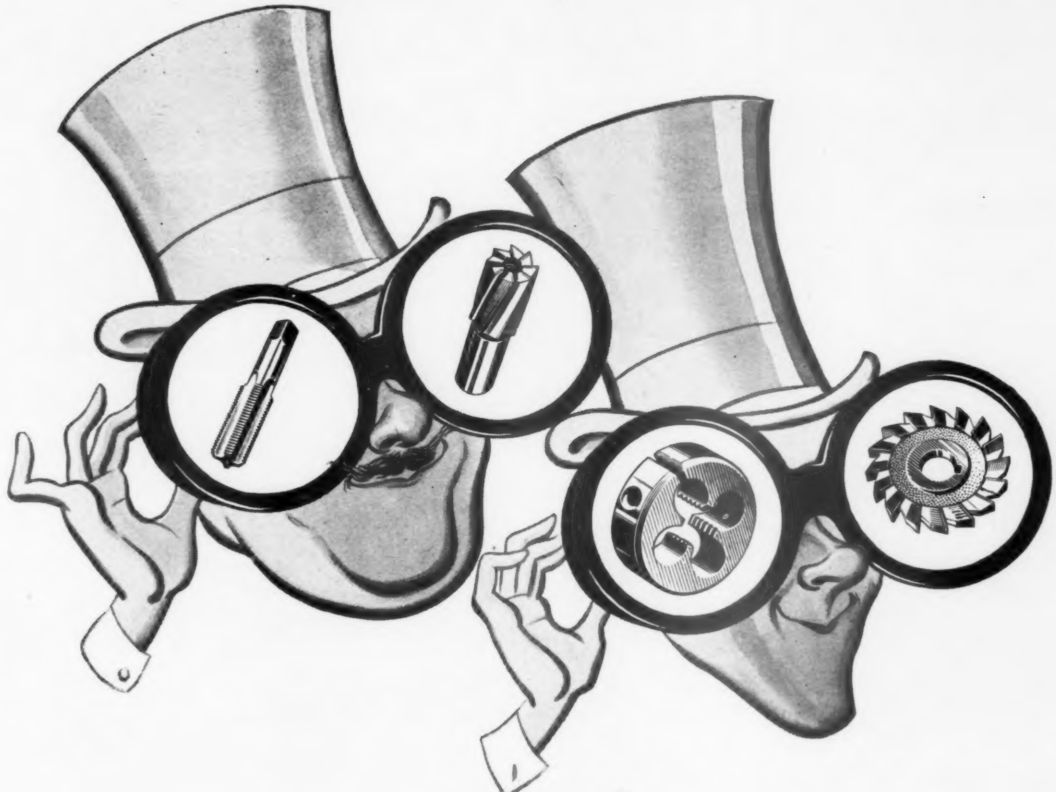

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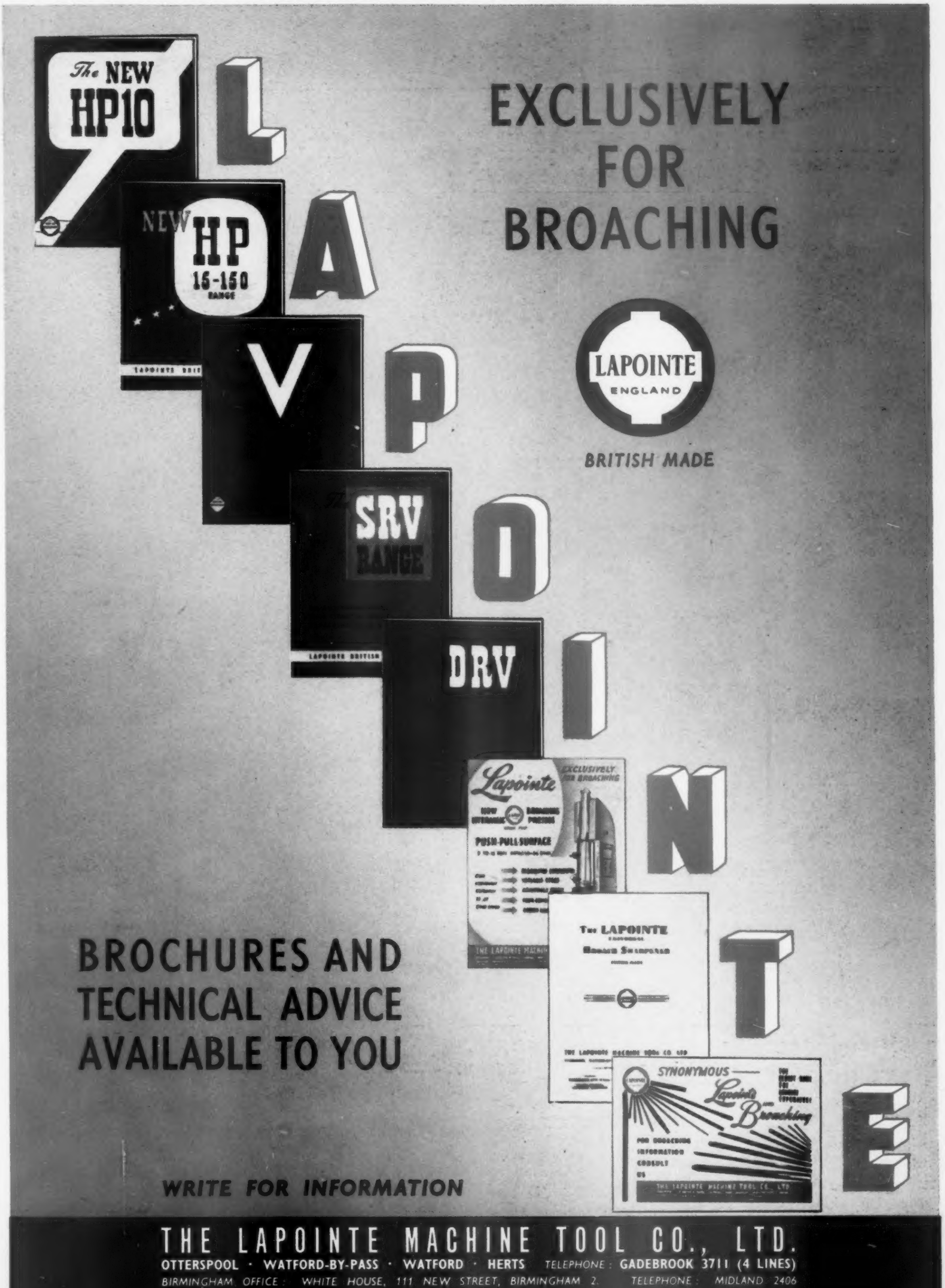
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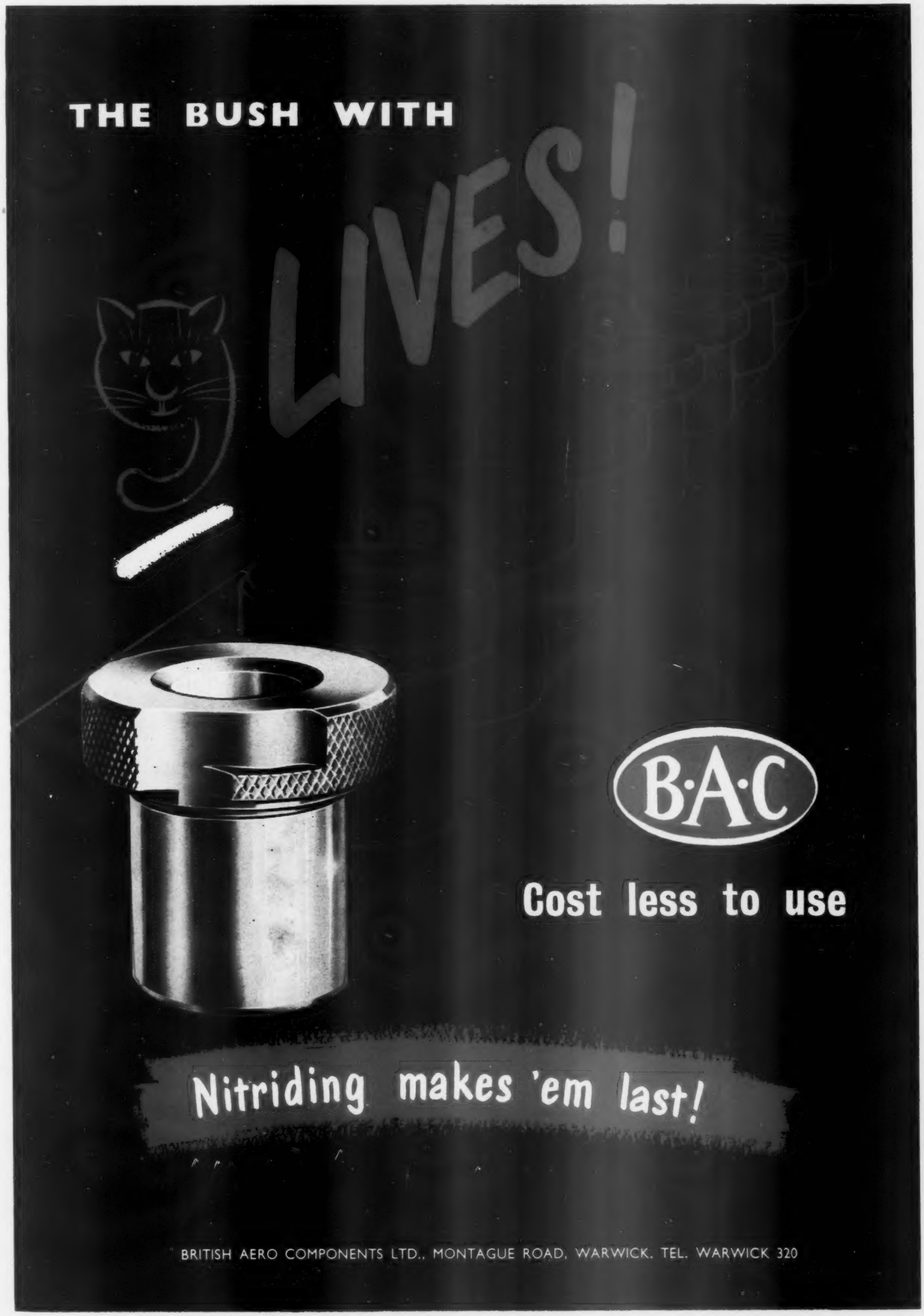
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Depreciation of Plant and Machine Tools

by Sir STANLEY RAWSON,
Vice-Chairman, John Brown and Co. Ltd.,
lately Director-General of Machine Tools, Ministry of Supply

LIKE so many words applied to technical uses, the term depreciation has become a term of art both to the accountant and the engineer; and in each field has become a term of controversy, the usual fate of a term of quality applied to quantity. Accountant and engineer are at one in thinking of depreciation as descriptive of the attrition or destruction of fixed or quasi-fixed assets used in the several processes of production. It is not the same as the wasting of a wasting asset—say a mineral property by reason of its being worked. In the case of minerals, broadly speaking, the value of the property as a whole is less, but the product from the property varies only with market conditions. Each piece of mineral is the same value as any other. In the case of machinery and plant, the lessening of value lies in the increasing inability of the machinery or plant to produce as good a product as it did before. To the accountant, capital goods present a problem in amortisation—the recovery of the results of previous " abstinence " expended upon them. The engineer recognises the need and propriety of amortisation, but seeks to measure the extent of lessened value differently from the process of a sinking fund.

Depreciation as an industrial concept was given substance by the Parliamentary draughtsmen who, in framing the clauses relating to industrial profits of the Income Tax Act 1842, tried to arrive at a satisfactory definition of what constituted profit. They did not attempt an abstract or philosophic definition. They declared profit to be what was left of the gross difference between income and expenditure after a number of deductions had been made. Among the deductions was " an allowance ", which the Commissioners authorised to deal with the assessment " may consider reasonable as representing the diminished value by reason of wear and tear of the machinery and plant used for the purposes of the trade or business and belonging to the person by whom it is carried on ". Fundamentally, this still remains the view of the Inland Revenue. Depreciation is the extent of the fall in the value of machinery or plant by reason of use in a business by the proprietor of that business. No yard-stick of measurement was stated. The means of measurement was left to the reasonable judgment of Commissioners. These for long held the view that where extensive repair or recondiitioning of plant was carried out, " renewals " replaced any depreciation. Gradually, however, by experience a large body of vital statistics of how long plant and machinery of various kinds last was gathered together in the shape of the long list of " permitted allowances " which fills many pages of the standard workh on Income Tax. At the same time, however, industrial value was equated to the quantum of capital expenditure. When the sum of the " allowances " is equal to the original cost, depreciation as such ceases; and if the sum of the accumulated allowances exceeds the original cost, the excess is an index of the degree of error in computing the several stages in the diminution of value, which the allowances are supposed to represent.

Change in Purchasing Power

Such a conception is, of course, admirable provided that the measurement gauges remain reasonably stable. In this simple conception monetary value is regarded as relatively static. Today this is quite different. Apart from the explosive behaviour

of many national currencies, the purchasing power of money has changed vastly and irregularly throughout the world. Things have become more valuable than money. We tend to look upon depreciation, not as measuring the wear upon plant and machinery, and wear and tear allowances as measuring the recovery of what has been spent, but as provision for what may or will have to be spent in the future. It is, of course, extremely difficult to see how any Chancellor of the Exchequer or any body of Commissioners could indulge in speculative guesses as to the prospective value of money over an enormous number of points of time in the future; and no Government could face the mass of inequities such a policy would cause. The contention is in fact an illogical reason for claiming, under the guise of depreciation allowance, a lightening of the burden of taxation; but underlying the suggestion is the feeling of uneasiness that the State is spending as revenue what common prudence requires to be reserved for the future.

Machines As Members of A Community

The great change in the value of money has however brought the problem of depreciation into high relief. This change coincides with a vast increase in the number, type and complexity, in scale and in detail, of modern instruments of production. What I have referred to above as the vital statistics of industry will, today, just not do. They have less and less relation to the present position; even less than has the simple idea that any given piece of machinery wears out along a simple rateable scale; and the gap between the monetary or " amortisation " value of a machine and its engineering value grows wider and wider. Engineering depreciation is the fall in the value of a machine in relation to the function it has to perform; this conception is wider than, but must necessarily include, obsolescence. We have to know the useful life of any machine; and " useful " is, of course, a relative term. Machines are very like human beings; not individual human beings, but the human groups whose fate and whose behaviour are measurable statistically. There are machines with short and brilliant careers; machines which plod along undistinguished furrows. They suffer from functional diseases; from accidents. This applies whether the machine is a production machine set up for longer or shorter runs on self-identical components, or whether it is a jobbing machine on intermittent production or maintenance work.

Many machines are, today, members of a community, probably as, say, in a motor car, or aero-engine factory, a community of highly diversified members or classes of members. The life of such a community is the life of the weaker members; and diminution of value may well depend not on the intrinsic worth of a machine, but on the group within which it is set.

Longevity in Machines

There are, of course, to be found in the machine world examples of remarkable longevity. These are mostly confined to machines originally designed to handle pieces or products of great weight and large dimensions, either in themselves or with their accompanying tackle. Examples of such machines are large diameter boring mills, long-bed and heavy-face plate lathes, and more recently, horizontal borers with large diameter spindles and big face millers. These machines were, and are, extremely costly and expected to last a long time. It was also in the minds of their designers that they might well have to handle larger and heavier pieces at quite late stages in their careers. It is probable that in the strict sense these machines never had any real economical justification. It is, however, quite impracticable without them to handle and machine the large castings and forgings needed for the main components of modern plants. The housing of a modern rolling mill, the cylinders and platens of extrusion and forging presses, the heavy hollow forgings needed for high-pressure and high temperature work, the large runners for hydraulic turbines, all need machines of this type. The output of these machines limits both the amount of, and the time within which, heavy operating plant can be available; and the machines themselves are limited to the castings and forgings which the steel works of the country can produce. The work on such machines is usually intermittent; and for reasons of manning it is difficult to work more than single shift. Setting times are long, and dimensional checking of the work limits seriously effective time. By reason of the large pieces involved in their operation, these large machines need careful periodic overhaul. Their life

expectation is at least thirty years, and quite a number exist—and are producing good work—which have reached their half century. In terms of cutting hours of life, even thirty years is short—probably not more than 30/40,000 hours at best. The probabilities are that these machines were from the outset enormously overdesigned. Depreciation must vary with the weight of the work and the material of the work. But even when cutting high tensile material, it is probable that the dead weight to be handled is the root cause of depreciation; and, from a practical standpoint, depreciation in the sense of amortisation could be related to the work piece weight along a logarithmic curve.

When we come to medium machines, we come into a region where the two great causes of machine mortality, fatigue and corrosion, find their largest field. The introduction some twenty-five years ago of the hard metal carbides as cutting tools involved a drastic overhaul of the linkages between the machine drive and the cutting tool. The elimination of chatter removed some of the fatigue risks, but introduced others by inducing vibration and by the loss of the safety link in the stalling of a belt drive. To reduce inertia forces machines were more lightly built and advantage was taken of the greater and more uniform strength of alloy steels. The improvements in the materials of machine construction were however accompanied by changes in the materials to be cut. Cast irons, today, even though of higher tensile, are less risky to a machine than the "hard spots" which not many years since could play havoc with the best of tools. On the other hand artefacts, such as bakelite, compressed fibres and polymers, bring in their train new chemical problems as well as mechanical. Depreciation in this class would appear inherently to depend upon what metal or material is cut and upon the degree of shock or vibration involved in reasonable cutting speeds. Rate-fixing is not an exact science, but in machine hour rating it is perhaps not too much to ask for differential depreciation on materials and energy of cutting.

The lighter class of machines generally consists of high speed machines, in many cases adapted for automatic cycles of operation or carefully jigged and tooled to avoid any but the smallest interruption in production. The life of these machines is accuracy. They must work within specified limits and the problem of their depreciation is the rate at which, and the time within which, they lose that degree of accuracy. Errors of the machine can sometimes be compensated by special jigging; but many repetition set-ups now make use of automatic gauges to indicate and register the inaccuracy and irregularity of the machine.

The Problem of Reconditioning

Depreciation of any machine is, of course, involved in the problem of reconditioning. At the present time, by reason of the incidence of taxation, there is far too much reconditioning of old machines. The cost of reconditioning is a revenue charge; the purchase of new machines is a capital expense. So long as taxation takes 60 per cent. to 70 per cent. of industrial profits this state of things will continue. Much uneconomic work is carried out on machines either obsolete or possessing only a limited life expectation after reconditioning. It is interesting to observe in this connexion that surveys of comparative costs of producing identical parts in several districts of this country showed the best economy in high wage districts, where only the highest class of machine was used.

Some part of the difficulties of depreciation arises from a practice, which is still prevalent among many engineers, of purchasing machines too elaborate in their equipment for the work they have to do. During the 1939-1945 War, large numbers of turret lathes were installed. Numbers of these were in store with one or two tool positions completely worn, with all the rest unused; and masses of attachments, which had never been used, were supplied with machines needed for limited purposes. It is, of course, easier and perhaps more economical to take a standard complex machine for simple purposes where the re-design and production of a simple machine would take too long; but far too many machines are bought which never are used to their full capacity. That is not depreciation; it is waste.

It would perhaps be wrong to close this article without some reference to the lessening of the engineering value of a machine which fails to take account of the changing and reasonable requirements of the operator. There are still too many quite high class machines today which make no provision for a rack or tray on which the operator can lay out his tools; a number more multiply speeds and gears far beyond any necessity; still more neglect accessibility. All these factors depreciate machines far more than any reasonable cause of mortality.

FUNDAMENTALS OF GAUGE DESIGN

by K. J. HUME, B.Sc., M.I.Mech.E., M.I.Prod.E.

Presented to the London Section of The Institution, 17th December, 1953

Mr. Hume received his early training at the National Physical Laboratory and, at the same time, studied for a science degree at The Polytechnic, Regent Street. He later joined the de Havilland Aircraft Company as Metrology Superintendent, remaining with the Company throughout the Second World War. For part of that time he was responsible for all inspection on the prototype Goblin gas turbine engines. For a period after the war he was engaged on development work with Messrs. Hilger and Watts Ltd. and in 1951 was appointed Head of the National College of Horology and Instrument Technology at the Northampton Polytechnic.

Mr. Hume has written various books and articles on engineering metrology and is a member of several B.S.I. technical committees. He is also a member of the Institution's Editorial, Papers and Standards Committee and is a founder member and Chairman of the Engineering Metrology Association.

Mr. K. J. Hume

THE fact that there is today an immense range of successfully manufactured articles, from lampholders to aero-engines, requiring various degrees of dimensional inspection, shows that the design of gauging and measuring equipment is a well-established science and art.

Gauges, inspection fixtures and all kinds of measuring equipment have received their due share of attention from production engineers in recent years and the problems involved are treated as routine matters in the modern production organisation.

Problems of gauge design and manufacture are solved in many ways, but if they are not dealt with in a scientific manner with an appreciation of fundamental principles much valuable time, labour and efficiency may be lost.

It is today a generally accepted principle of product design that the widest possible tolerances, consistent with proper function and other design requirements, should be applied. It is recognised that time spent in maintaining unnecessarily close tolerances is completely wasted and all good designers are aware of the economic significance of every line and figure on a drawing.

In the design of gauging equipment the same principle will be applied although perhaps rather more conservatively. In many cases gauge tolerances are necessarily small and designs are produced which demand a high precision of manufacture as an inevitable right. It is therefore important that the precision necessary in any piece of gauging equipment should be designed into it as far as possible and should not have to be achieved by excessive demands on manufacturing accuracy.

An example of what is meant by this is provided by a fixture for checking the division of the three or four arms of the hub of a variable pitch propeller. These fixtures were designed before the last war and it is possible that several are still in use, which is unfortunate for those who have to use them.

The principle of the fixture is illustrated in Fig. 1a. A central vertical pillar mounted on a cast iron plate supported the propeller hub on its axis of rotation, various splined and coned adaptors being used. Three (or four) steel straightedges were secured to the plate and these represented the standard of radial alignment and angular division against which the hub was checked. The method of operation was to locate the stand of a dial gauge against the straightedges while the gauge registered on the arms (Fig. 1b). The plate was of solid cast iron about two inches thick.

Let us examine some of the defects of this design and see how they could be eliminated.

(1) Although not necessary for a standard of straightness, the plate obviously had to be flat. Any variation in flatness which caused the dial gauge to tip towards or away from the arm being measured would introduce a spurious divisional error. Due to the fact that the plate was not webbed, such variation was a certainty even if the plate had been flat originally.

(2) The straightedges had to be ground straight, located and dowelled on the plate without distortion in true position. The maintenance of any reasonably stable accuracy proved impossible.

There are various ways in which the division and alignment of the hub could be checked; some were, in fact, used in a later design. Fig. 1c illustrates the principle of a method which would considerably improve accuracy.

If the hub were mounted with its axis horizontal an indicator, supported on an independent surface plate, could check the radial alignment of the arms. If each arm were located in turn against a fixed stop, the indicator would show any variations in the 90° angle between pairs of adjacent arms.

In this case, since the four angles must total 360°, whatever the individual errors, the algebraic sum of the errors must be zero. The mean of the four indicator readings thus corresponds to a true 90°. The method can be extended to any number of divisions and is known as the calliper method. It is capable of the highest accuracy.

The Principle of Alignment

As in the case of the fixture just quoted, there are many applications of dial gauges and other instruments where errors in guiding ways will be reproduced in the measurement unless certain principles are adhered to. To make this point perfectly clear, it is perhaps easier to look at the use of a dial gauge in a vertical plane, in checking the parallelism of a horizontal bar or surface to a surface plate. Setting the gauge with a considerable overhang as in Fig. 2a is more likely to introduce errors than the setting at (b) where the gauge support is directly under the line of measurement.

One more example, which may not be quite so obvious, is provided by the ordinary vernier calliper. This is not, of course, an instrument of high precision, not only because of its low magnification but also because of its principle of design. Reference to Fig. 3 shows that, if the beam is not straight, the dimension measured is not equal to the movement of the slide along the scale.

It is true that a calliper has to be badly worn for this error to become serious but there is another machine of high precision where the same conditions apply. This machine is the jig borer, in which it is inevitable that the scales, lead screws or other method of measurement must lie at appreciable and, in fact, varying distances from the plane of the work. A tall casting could easily be some two feet or more above the line of measurement of the table traverse. Over a traverse of, say, 10 inches, a straightness error of

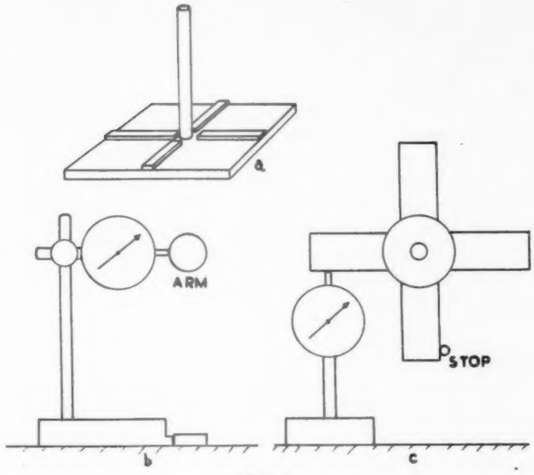


Fig. 1

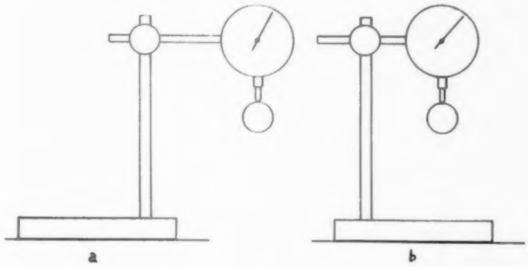


Fig. 2

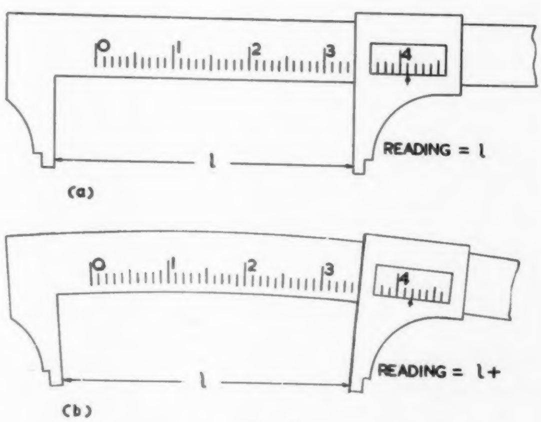


Fig. 3

0.0001 in. on the guiding ways will introduce a positional error of about 0.0008 in. for every 10 in. of height. This is of course an excessive error for such a machine.

Errors from this cause will be minimised if the line of measurement is made to coincide with the line of the scale of reference. In any measuring device therefore this alignment must be maintained as far as possible. As in the case of the jig borer, compromise is often necessary for practical reasons. The ordinary micrometer calliper complies exactly with this principle, which enables its accuracy to be maintained over long periods of quite hard use.

Kinematic Design

The principle of alignment is probably the most important factor in the design of precise measuring equipment. Next in importance is the observance of kinematic principles in these designs. To some, who may know a little of these things, the term "kinematic design" suggests a type of spindly instrument, assembled in a precarious manner, which falls to pieces at the slightest touch. "Such designs" they say "may be all right in the laboratory but are useless for ordinary engineering work. Give us something substantial which cannot be pushed over."

These people are both right and wrong. Instruments of strict kinematic design are sometimes, but not always, unsuitable for use in the works. The art of the gauge, instrument or machine designer must be used in understanding the theory and modifying its application to the known conditions of service.

It will be appropriate, at this stage, to consider the principles underlying kinematic design. Any body, in free space, has six degrees of freedom, three of translation and three of rotation. This bald statement is rather obscure and probably discourages many a potential student of the subject. Consider an object, such as a book, being held in the hand. The book is moved to another position by moving the hand, at the same time giving it a rotation. The book could move from one position to any other by an infinite number of different paths, each of which could be made up of straight lines or curves. Similarly the number of ways in which the book could be rotated to move from one attitude to the other is also infinite.

If three axes in space are chosen, it is possible to move a body from one point to any other entirely by movements parallel to the three axes (Fig. 4a). The axes need not be mutually perpendicular but it is usually convenient to choose them to be so. Any change in attitude can be accomplished by suitable rotation about axes parallel to the three axes (Fig. 4b). Fewer than three axes will not cover every condition since motion would be restricted to one plane or one line.

There is a basic principle in the kinematic design of the relative location of two bodies, such as two components of an instrument or machine. The number of points of contact and the number of degrees of freedom remaining should always add up to six. The sum *cannot* be less than six but, if it is greater, some of the points of contact are redundant

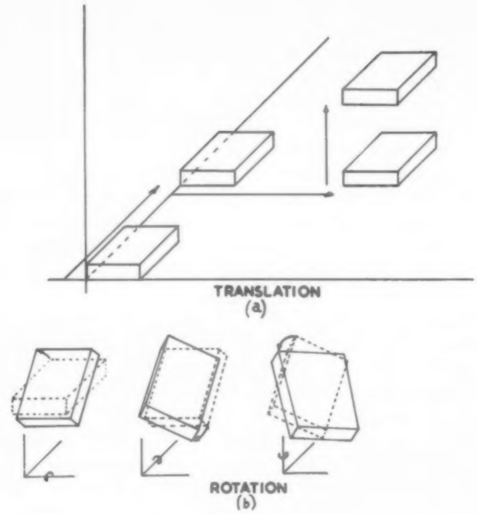


Fig. 4

and thus duplicate the function of others. It is this fact which causes stresses and strains in an assembly and gives rise to most of the close tolerances in manufacture which appear to be necessary today. A few examples will illustrate the principle.

A sphere resting on a plane has, in theory, only one point of contact, provided that it is held in contact by gravity or some other closing force. The sphere can rotate about any of the three chosen axes and can move along two axes lying parallel to the plane but cannot move along an axis perpendicular to the plane. Thus, there are five degrees of freedom left when there is one point of contact.

A body resting on a plane at three points, a three-legged stool for example, can rotate only about an axis perpendicular to the plane and can be translated in two dimensions parallel to the plane. Thus, three points of contact leave three degrees of freedom. If another leg is added to the stool it will rock, showing that there is a redundant location, only three points being in contact at any time.

At this point we can consider some examples which have a direct bearing on engineering practice. A ball located in a conical hole would appear to contravene the whole principle by making line contact with the hole. It will, however, normally make contact at only three points. If either the ball or hole is not true in form these points may change, again producing rock or shake. The hole may be formed in such a way that three definite points of contact with the ball are provided. This may be done by making the hole in the form of a triangular pyramid so that the ball makes contact with three planes. Three degrees of rotation only are left, thus satisfying the kinematic principle. Let those who consider kinematic designs to be delicate remember that the standard method of supporting the whole weight of large radio masts is on a single steel ball only a few inches in diameter.

Machining on centres involves a slight modification of this example. Here, there are six points of

contact, three at each end. Since gravity is not relied on as a closing force, one of the points can be considered to provide this force by putting the assembly under a slight elastic strain. One degree of freedom, rotation about a single axis, remains. If the centres in the work were made trihedral and the machine centres spherically ended, even greater accuracy should be possible, although load carrying capacity would be reduced.

A highly accurate and practical method of locating two components in exact relative positions is by the hole-slot and plane location or the three slot location, illustrated in Fig. 5. Three balls on the one component locate respectively in the trihedral hole with three points of contact, in the vee-slot with two points of contact, and on the plane with one point of contact, making six points in all and leaving no degrees of freedom. Accuracy of ball positions, within quite wide limits, is not important. For this reason, such a method of location will accommodate differential thermal or other changes of shape without setting up stresses. The alternative of three vee-slots provides two points of contact on each slot. Again, no great accuracy of manufacture is necessary.

Although many further examples of kinematic design could be given, there is space here for only one more application, that of one degree of freedom, in translation along a line. In measuring instruments and gauging devices this is undoubtedly the commonest movement, apart perhaps from that of rotation. How often is it designed in a cumbersome, expensive and inaccurate manner? The familiar dovetail slide is the curse of both manufacturer and user with its multiple surfaces, awkward angles and tricky adjustments for wear. In the nature of things, wear is never uniform and consequently one has to suffer tightness and looseness in different parts of the movement.

The simplest form of kinematic design for a linear translation is provided by a carriage supported on

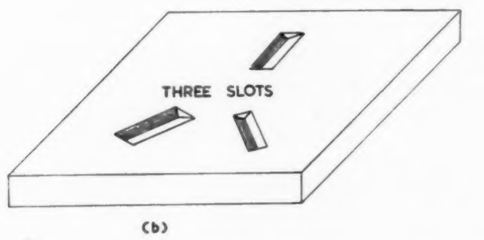


Fig. 5

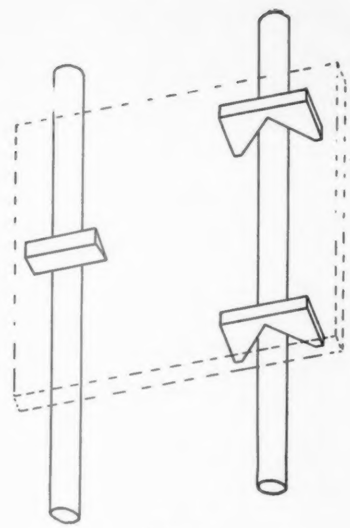


Fig. 6

two parallel cylindrical rails. Two knife-edge or rounded vees, one at each end of the carriage, make four points of contact on one rail and a fifth knife edge or cylinder near the centre rests on the other rail (Fig. 6). There are several variations of this type of support, including the familiar vee and ball support for a floating carriage. The beauty of the method is the ease with which an accurate straight line motion can be obtained; in the method described, it depends only on the straightness of the surface of one bar. There need be no tightness or looseness and no adjustment for wear.

The only effect of slight lack of parallelism between the bars or vee grooves is that the carriage will wind as it moves along; this may not be important in some applications.

Modified Kinematic Designs

The important thing for the practical designer to know is where kinematic principles can be applied in a modified form to suit conditions of load or robustness. Even with the strictest designs, theoretical point contacts are never actually realised but, even if they were, the effects of such a thing as indentation of ball locations cannot be ignored.

Departures from kinematic ideals inevitably increase the demands on accuracy of workmanship but even semi-kinematic designs usually show considerable savings on traditional engineering methods. Taking the case of the linear translation as an example, we can see that knife edge locations on cylinders or balls rolling in vees will not carry much load without serious indentation and loss of accuracy. The knife edges must therefore give way to plane surfaces and immediately, the relative alignments of the surfaces have to be controlled.

Again, with use, the surfaces will begin to wear and acquire slight grooves; flats will be worn on the

bars or indentations will appear on vee surfaces. Quite often, both alignment and wear problems can be minimised by lapping the vees with a bar of the same diameter as the bars or balls they will rest on. The initial alignment accuracy need not then be high and the contact area is greatly increased with a minimum of trouble and very little loss of accuracy.

If every designer of gauging equipment and machine tools would give this method even passing consideration, the accuracy of such equipment would often be greatly improved with considerable saving in cost.

The dangers in the design of the end-thrust bearing for a lead screw have received a certain amount of publicity, particularly from the N.P.L. The periodic error introduced by errors of squareness in a thrust collar can be eliminated by using a ball located in a cone centre of the screw and bearing on a flat plate. It may justifiably be considered, in certain applications, that the thrust is too great for a virtual point contact. An alternative to the ball thrust is to mount the thrust collar on gimbals in which two rings are pivoted on axes which are mutually at right angles. This could be made to take a higher load but would demand a somewhat greater accuracy in manufacture.

One of the practical disadvantages of some kinematic designs is their relative instability. A typical example of this is the method of mounting a carriage on three balls, resting in vee grooves in a base, in order to provide free linear translation or "float". The upper carriage has a vee and a flat, the vee resting on two balls and the flat on one as shown in Fig. 7 (a and b). A familiar application is the floating carriage type of screw diameter measuring machine. Since the carriage moves along faster than the balls, as in a ball race, it can easily happen that, if the distance moved is appreciable, its centre of gravity will move outside the triangle of support with consequent instability (Fig. 7c). Furthermore, the balls between the two vee grooves will move faster than the ball between the vee and flat. In the case of the diameter machine the amount of movement is limited since only a small float is required and, in addition, the balls are not single but in groups of two or three, a departure from strict kinematics but a useful practical design. Where the load is too great or accidental indentation is likely, ball contacts on a plane surface can often be replaced with self-aligning pads, suitably cupped for the ball foot. A spherical seating for the ball brings back the dangers of inaccurate positioning; this seating should therefore be trihedral or conical if possible. A suitable spring closure to keep the ball on its seat will usually prevent indentation.

Rigidity

When one has to be concerned with fine measurement, it is soon realised how flexible everything is, even the most substantial casting. Gauging and measuring equipment has therefore to receive particular attention in this respect, both in its design and in its use in the works.

The proper webbing of heavy or extensive units is essential and, in designing such equipment, careful consideration and calculation must be given to weight, loads and deflections. The standard surface plate, made by a reputable manufacturer, is an excellent example of proper design for rigidity and accurate support.

There is often some doubt as to the proper method of supporting a straightedge; this is sometimes confused with Airy's method of supporting a line-standard or end bar. Sir George Airy, a former Astronomer Royal, supported the Imperial Standard Yard on a frame of eight rollers arranged in the manner shown in Fig. 8a. The spacing of the rollers was $\frac{l}{\sqrt{n^2-1}}$ where l is the length of the bar and

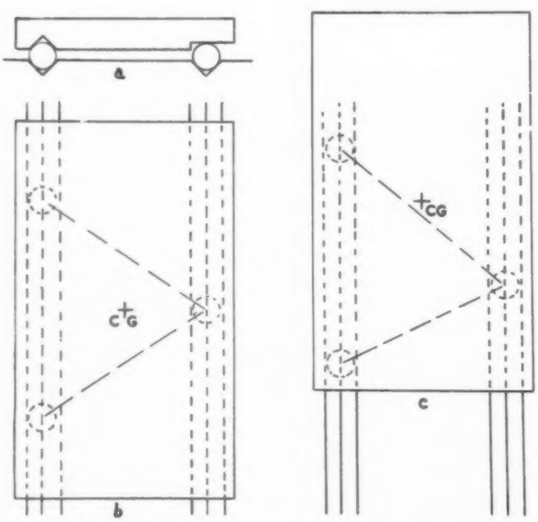


Fig. 7

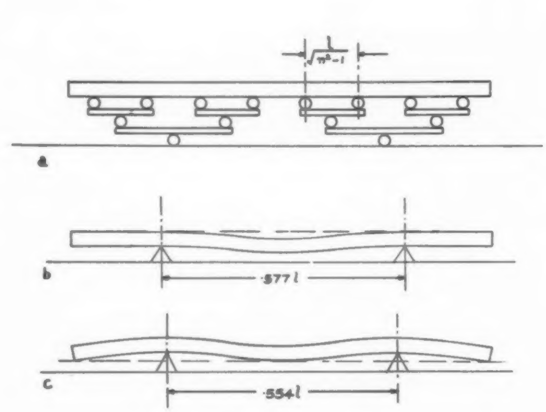


Fig. 8

n is the number of rollers. It was subsequently found that two points of support were sufficient, their separation then becoming .577l (Fig. 8b). These points are known as "Airy" points and when thus supported the extremities of the bar are horizontal. An end standard, when used horizontally, should also be supported in this way since its end faces will then be parallel.

Support of a straightedge at its Airy points will not, however, provide minimum deflection. The correct separation of the supports for this condition is 0.554l, bringing the sag of the ends level with the sag in the middle (Fig. 8c). Use of this fact in the design of certain types of gauging and measuring equipment can increase and maintain accuracy and, in many cases, permit lighter construction than would otherwise be practicable.

Dial indicators will often be found mounted on thin arms or extensions. It is argued that, even if a deflection is present, it is constant and will not affect the reading. This is far from being true. A definite pressure, usually several ounces, is required to operate the indicator and, furthermore, the pressure increases as the plunger is depressed. If small variations are being measured, e.g. less than 0.001 in., it is quite possible for the indicator support to be deflected without there being any movement on the dial. The tool and gauge designer cannot afford to forget his strength of materials theory even though he is not building bridges.

Measuring Contacts

Most gauging or measuring devices, except those which are purely optical, magnetic or capacitive, have some form of mechanical contact with the work to be measured. The shape and form of such contacts must be carefully considered in the light of function and gauge manufacturing accuracy.

A device which measures or gauges between parallel faces, such as a micrometer or gap gauge, must be capable of alignment with the work; and its faces must be flat and parallel to an accuracy consistent with the accuracy of measurement. A flat contact tip should not be used on a comparator or dial gauge unless means are available for its adjustment to parallelism with the work table or opposite anvil. Where cylindrical or parallel faced work is measured, it is better to provide a spherically ended comparator tip. Such a tip is essential if the *forms* of the work and setting standard are different, as in the case of cylindrical work measured on a comparator set with slip gauges. For the measurement of very small diameters, such as needle rollers, a larger radius than normal on the contact tip is a great help. With the usual radius, of say $\frac{1}{4}$ in. or $\frac{1}{8}$ in., the maximum point is passed very quickly and the exact maximum reading can easily be missed.

Design of Limit Gauges

Although it is not within the aims of this Paper to discuss the details of design or tolerances of limit gauges, they form the largest proportion of all the gauges in use and must be considered from several points of view. The term "limit gauge" covers a much wider field than straightforward plug, gap or ring gauges for simple dimensions. Simple dimensions, such as plain cylinders, are not, incidentally, so simple as they may appear.

Limit gauging applies to the gauging of components of any shape, including screw threads, tapers, splines, etc., where the work is not measured but merely checked for compliance with certain limiting dimensions. Another form of limit gauging is that carried out with a comparator or other indicating device. The operator is not expected to take a reading but merely to observe whether the indication falls between two pre-set positions. This method has distinct differences from the use of fixed gauges and, strictly speaking, is not a fully adequate method of limit gauging.

Taking the example of a cylindrical shaft whose diameter is specified on the drawing by a single toleranced dimension, there are several features which have, or ought, to receive attention. The tolerance on simple diameter must include variations in roundness and straightness so that the shaft would enter, for its whole length, a perfect cylindrical hole of diameter equal to the upper limit on the shaft diameter. Thus the "Go" gauge must be of such form that it will ensure that this condition is satisfied. It should, in fact, be a ring gauge which will engage, all at one time, the full length of the shaft.

The lower limit cannot, however, be checked in the same way. All errors of form make the shaft effectively larger; the minimum diameter must therefore be checked on single diameters at all points on the shaft. The "Not Go" gauge must therefore be in the form of a calliper which will detect any point at which the diameter falls below the lower limit.

This introduces an important principle of limit gauging, known as the "Taylor Principle" after William Taylor who first laid it down in 1905. This principle requires that a "Go" gauge shall check all the dimensions of the component in what we now call the "maximum metal" condition, thus including all the errors of form and shape which will have the effect of adding metal to the simple measured dimensions. "Not Go" gauges must check only one dimension at a time for the "minimum metal" condition. It will be apparent from this that several "Not Go" gauges will be required for the various elements of a complex component such as a screw thread or spline.

This principle has long been recognised in the gauging of screw threads where errors of pitch, angle and form of thread increase the simple effective diameter, as measured with wires, to an amount known as the virtual effective diameter. A full form "Go" gauge is always used and the "Not Go" gauges should check separately major, effective and minor diameters. In practice the effective diameter gauge is often the only "Not Go" gauge used.

Strict adherence to the Taylor principle is not always practicable. A shaft is seldom checked with a full length "Go" ring gauge but the known accuracy of production is assumed to control errors

of form within reasonable limits. Even in a simple shaft, however, the effects of lobing can cause unsuspected trouble when a straightforward "Go" calliper gauge is used. Full form checking of screw threads, splines and other components, where perhaps several operations are involved, is always advisable.

Limitations of Limit Gauging

There has been a marked tendency, in recent years, for fine tolerances to be applied to increasingly large dimensions. The advent of the jet aero-engine in particular has been responsible for many such demands on production and inspection facilities. The use of plain limit gauges for fine tolerances on large sizes is definitely uneconomic and unsatisfactory.

Some years ago the Author was responsible for introducing, more by persuasion than force, a system whereby minimum gauge tolerances were specified for various sizes of plug, ring and gap gauges. This principle was adopted by the B.S.I. in the recent edition of the specification for plain limit gauges, B.S.969-1953. A table is provided giving related sizes and minimum tolerances for limit gauges. The table recommends, for example, that a gauge tolerance of 0.00006 in. (0.0015 mm.) should be the minimum specified for a plug gauge between 0.5 and 1.0 in. (13 and 25 mm.) diameter and a tolerance of 0.0004 in. (0.010 mm.) should be the minimum for a ring or gap gauge between 5 and 7 in. (125 and 175 mm.) in size.

The figures given in the table are recommendations only and it is realised that there will be certain applications where they cannot be followed. The difficulties of manufacture, checking and use of large-size-fine-limit gauges are considered to be such that, where the work tolerance would demand their use, direct measurement methods should be used on the inspection and manufacture of the components.

Such direct measurement involves the risks inherent in avoiding the Taylor principle but is a necessary compromise. Provided that all concerned are aware of the risks and take appropriate steps in production and inspection to minimise the effects of accumulation of errors, comparator methods of gauging large dimensions can be quite satisfactory.

Comparator Gauges

Comparator gauges for large dimensions present several design problems. The gauge must be rigid, easily handled and must indicate accurately any variations of the measured dimension from the setting standard used. The form of its measuring contacts must be correct and the transfer mechanism from the contact to the indicator must operate freely and accurately. Because of their size, gauges of this type often have to be supported on the component itself, on and end face or flange for example.

There are three general methods of constructing the body of such a gauge, light alloy casting, fabricated structure in plate or tube and single tube construction. A casting or fabricated structure can be designed to be rigid and relatively light if an estimate of bending moments is made. A steel tube can be quite thin-walled and yet quite rigid if its diameter is proportioned to its length; it is often the simplest, cheapest and best solution. Whatever construction is used, it should be provided with insulated handles suitably placed for convenient operation and balance.

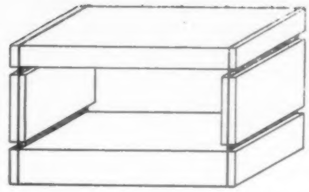


Fig. 9

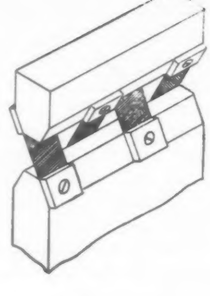


Fig. 10

The transfer of movement from the measuring contact to the indicator must be positive, of uniform magnification (often only 1/1) over the working range and free from appreciable friction. A direct plunger is simple but is liable to stick through dirt, oil or damage. A good method of supporting a transfer link required to move in one line, or approximately so over a short distance, is shown in Fig. 9. The measuring contact and the indicator thrust contact need not be in the same line if only small variations are to be measured.

A pivoted lever appears simple but can provide many pitfalls. The practice of pivoting such a lever on a dowel pin is not recommended; it is better to provide conical bearing which can be adjusted for tightness. All such bearings should be of hardened and lapped steel. The crossed-strip hinge, shown in Fig. 10, is easily made and is quite rigid. It will provide "millionth" accuracy of repetition where required if the deflections are kept small. It *cannot* be relied on however to provide an accurate and consistent axis of rotation over more than a few degrees.

If supporting locations are provided on the comparator they should be designed so that the measuring contacts can measure a true diameter, if a diameter is to be gauged or the geometrically correct dimension in other cases. Location of the setting standard should be made at the same points on the gauge or on other suitable locations which are accurately positioned. In particular, the alignment of vees intended to locate an end bar must be accurate. Certain of these locating points may well be made adjustable, provided they can be securely locked and sealed in position.

A word of warning about three-point comparator gauges for internal diameters will be appropriate. It is very tempting to design a gauge with three contact points spaced 120° apart, two being fixed and one

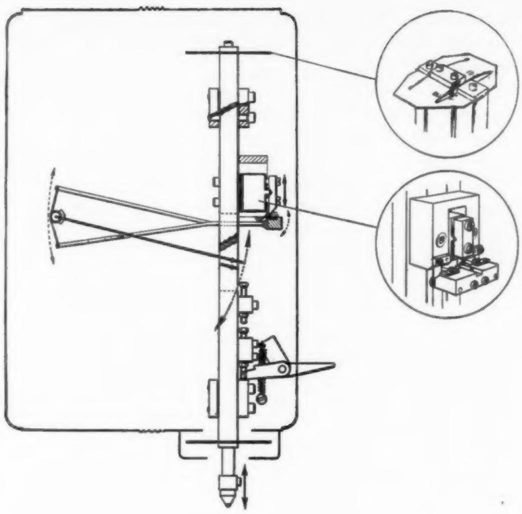


Fig. 11
(*Courtesy of Sigma Instrument Co. Ltd.*)

being the indicator. If the bore to be measured happens to be oval this gauge will not detect it but will show only a small proportion of the ovality. It is also true that a two-point gauge measuring across a diameter will not detect three, five or other odd-numbered lobing of the diameter but it is usually the safer type of gauge to use. These risks of uncertainty in measurement are the price we pay for abandoning the Taylor principle.

Design of Measuring Instruments

Although this Paper is primarily concerned with the design of single-purpose gauges, a great deal can be learnt from the study of modern measuring instruments. There has been a marked tendency in recent years to use standard measuring equipment for production inspection, either in its own right or incorporated in specially designed gauges or fixtures. Many of the best-designed instruments incorporate kinematic and semi-kinematic details but are, at the same time, extremely robust.

On one well known comparator the vertical measuring plunger has, until recently, been located on ball tracks. Vertical movement of the plunger was converted to arcuate movement of a pointer over a scale by the twisting effect of two transverse strips, one being attached to the plunger and the other to the body of the instrument. This instrument has recently been redesigned on slightly different lines as shown in Fig. 11; no departures from the sound principles which influenced the earlier design have, however, been made.

The plunger is now mounted on flat slotted springs, top and bottom, details of which are shown in the upper inset. This form of construction has undoubtedly helped production of the instrument and, at the same time, has reduced frictional hysteresis in operation. The vertical movement is applied to a sapphire contact on a pivoted lever by a knife edge attached to the plunger. The pivot of the lever is a crossed-strip hinge, already described, and it can be seen in the lower inset how the radius at which the knife edge acts can be finely adjusted to set the magnification. The final stage of magnification is obtained by the long arm of the lever which rotates the pointer spindle by a flexible strip wrapped round it. The point to note in this design is the complete absence of any precisely fitting or sliding parts. The components can be manufactured in quantity to reasonable tolerances, the precision of the instrument being inherent in the design. The ultimate accuracy is obtained by simple adjustment and not by precise manufacture of the component parts.

Fig. 12 shows the principle of operation of the indicating system of a pneumatic gauge manufactured by the same company. The method of obtaining magnification by the wrapped strips and the use, once again, of the crossed-strip hinge are apparent from the diagram.

Admittedly, these examples lie in the field of instrument, rather than gauge, design but appreciation of their simplicity, accuracy, robustness and ease of manufacture should make every gauge designer blush if he has ever specified a detail such as a lapped bar in a close-fitting hole for the transfer of a small linear movement. He should also plead guilty to waste of toolmaking skill and inefficiency in

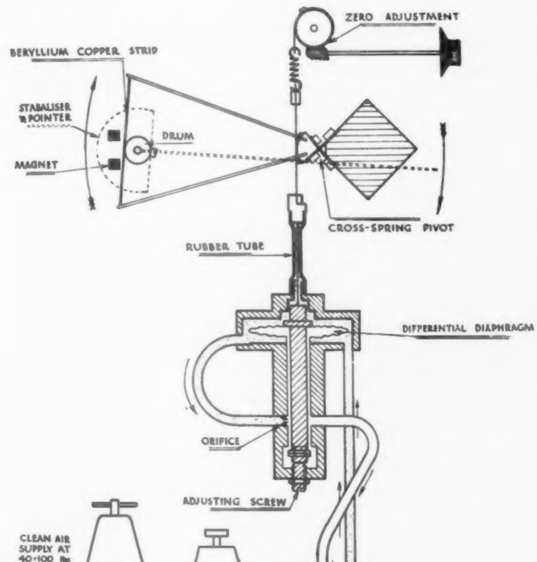


Fig. 12

(*Courtesy of Sigma Instrument Co. Ltd.*)

design for every dowel type pivot, dovetail slide, or other unnecessarily precise construction he has demanded where a near-kinematic design would have served the purpose.

Conclusion

A subject such as this cannot be adequately covered in a single paper or even in a complete volume. The design of efficient and accurate gauging equipment is a matter of combining practical experience with sound theoretical principles. The use of either one to the exclusion of the other is doomed to failure.

A short bibliography relating to the subject is given below. Of the books mentioned there is one which should be read by every designer of gauges, instruments and machines. It is Professor Pollard's "Kinematical Design of Couplings", a small book packed with scientific common sense which cannot fail to throw new light on the problems of design of gauging equipment.

BIBLIOGRAPHY

POLLARD, A. F. C., "*Kinematical Design of Couplings.*" *Adam Hilger.*

STEEDS, W., "*Mechanism and the Kinematics of Machines.*" *Longmans Green.*

ROLT, F. H., "*Gauges and Fine Measurements,*" *Vol. II. Macmillan.*

HUME, K. J., "*Engineering Metrology.*" *Macdonald.*

British Standards relating to gauge design:

B.S.919. Screw Gauge Limits and Tolerances.

B.S.969. Plain Limit Gauges.

B.S.1044. Designs for Limit Gauges.

DISCUSSION

Mr. W. R. Crook, who opened the discussion, said that gauging designed to check the finished product was not necessarily helpful to the machinist. The point Mr. Hume had raised with regard to more flexible means of measurement for the production departments was one which should prove particularly fruitful during the discussion.

In this connection, Mr. Crook would like to offer a couple of practical suggestions. In the case of grinding close limit holes of small diameter, the plug gauge of conventional form was not very helpful to the operator in obtaining his ultimate size, as he worked on a trial and error basis.

This could be illustrated by drawing a plug gauge of generous proportions. It was customary in some works to grind a small lead on the front to give the operator a guide as to when he was getting near his size. But unless he happened to hit right on that size it did not help very much. He could not deduce what his next move should be. Similarly, it suffered from another serious defect, particularly in grinding work where a little abrasive might get caught in the lead and score a hole—and possibly the gauge. The scope could probably be enlarged by dealing with this in another way and thus eliminating the difficulties. It was known that 17 minutes of angle produced a geometrical change of 0.005 in. per inch. One could, on the "Not go" gauge, grind an included angle of 17 minutes. There was, say, 0.0005 in. tolerance on $\frac{1}{2}$ in. hole. Halfway up was the tolerance, and the operator knew the target at which he was aiming was not something his gauge had to enter. He gauged on the taper in the front and, at the point of entry, he could immediately determine how much to move the slide in order to find the mean. This should be the target because of the great advantages in regard to gauge life.

In trying to help the operator to achieve his size, one occasionally came up against a few problems of another nature. Mr. Crook would like to draw attention to one such case because it would be a matter for future developments in machine design. It was brought to his attention some time ago that some male and female spigot registers had to be produced on the vertical boring mill. They were well in excess of 20 feet in diameter. The draughtsman, in his generosity, gave a tolerance of 0.01 in. To make it more difficult, he designed the part with an obstruction in the centre so that one could not get a bar gauge across it. The problem was easily solved in the end. The diameter of the vertical boring mill table had been measured in relation to the two pillars and a pad was fitted to one of the columns. The distance between the centre of the table and the measuring pad was then measured, and instead of 20 feet, there was only 9 inches to measure. The object was achieved with the height gauge.

The feature of adding measuring pads to machines was started some years ago but it seemed to have been neglected more recently. Some old lathes and some milling machines had them. Today even the most modern machines had magnetic indicator stands but nowhere on the machine to put them unless one added them oneself.

From the producer's point of view fixed limit gauges had restricted application. It was better to be able to measure the work immediately prior to the final cut, and the very simple instances he had quoted were intended as a guide to what could be done in this direction. If it were possible to provide some facilities to increase the operator's confidence in his ability and his work, one might eventually remedy one of the common causes of excessive gauge wear

brought about by the present understandable practice of keeping strictly on the safe side of the tolerance.

Mr. F. H. Rolt, in a written communication read by Mr. L. W. Nickols, said that a few weeks ago he was a member of a delegation from the B.S.I. Committee on Gauging Principles and Practice which attended an international conference on Limits and Fits. The Conference discussed, amongst other subjects, the question of gauge designs. The object of the discussion was to formulate a series of recommendations for the designs of various types of gauges best suited for controlling work pieces between prescribed limits, such as those set out in the I.S.O. system of Limits and Fits. The discussion was confined to gauges for plain shafts and holes, but even over that limited field many points were covered of which little mention was made in the Paper. The "Taylor principle" figured largely in the early talk at the conference and a considerable amount of time was taken up in discussing the compromises which had to be adopted when that principle was applied in practice. For example, a tentative table was formulated setting out the various types of "Go" and "Not Go" gauges recommended for holes, as one proceeded from small to larger sizes. With the increase in size of the hole, this table provided for the form of the "Go" gauge to change from a cylindrical plug first to a spherical plug and then to spherically-ended plates and cylindrically-ended plates until for the larger sizes the gauge became a spherically-ended rod. At what diameter of hole the form of the gauge should change was a matter of considerable discussion: it depended largely upon the weight of the gauge, how it could be handled and the cost of manufacture. It was fully realised, of course, that for the larger sizes as soon as one departed from a full form cylinder for such "Go" gauges, one transgressed the Taylor principle and ran the risk of false results due to errors in form, such as lack of roundness and parallelism of the holes tested. This risk became accentuated, of course, when one was dealing with relatively thin-walled holes.

This question of the various designs of gauges for holes ranging from small to large sizes was one which Mr. Hume might well have dealt with in his Paper, having in mind the present recommendations on that point in B.S.969.

Another point which Mr. Hume might have mentioned in his Paper was the common case of gauging tapers such as those of Morse taper shanks and sockets. The desirable use of short taper gauges for the "Not Go" tests near the ends of such tapers as a check on their angles might have been emphasised.

It was points such as these, actually dealing with gauge designs, which might have been mentioned rather than the principles of alignment and kinematic design and other matters which, in his opinion, were much more relevant to the design of measuring instruments than gauges.

Speaking of kinematic design, Mr. Hume rightly mentioned that, like the Taylor principle, the principles of kinematic design often had to be subjected to some drastic adaptations in practice, such as, for example, when designing slides for carrying heavy loads, where point contacts had of necessity to be replaced by sliding surfaces of appropriate area.

To return to the actual heading of the Paper, he was disappointed to find that Mr. Hume had very little to say about the more complicated types of gauges, such as receiver and position gauges. Such gauges were notoriously difficult to manufacture accurately, and if designed in what might be termed a solid form, they suffered from the disadvantage that if the work piece failed to assemble with the gauge it was generally difficult to say just where the work was in error. Wherever possible, it was better to design such gauges with loose "Go" and "Not Go" feeler pieces for inserting between reference faces on the body of the gauge and the work piece after the latter had been inserted in the gauge. Alternatively, the gauge could take the form of a jig fitted with dial-gauges for contacting the work at the various points to be gauged as regards their relative positions. Such position gauges with feeler pieces, or dial-gauges, used in conjunction with setting masters, were much more satisfactory in use, as they enabled an inspector to identify particular errors in the work piece, and if necessary the requisite adjustments could be made to the manufacturing jigs. Incidentally, the setting masters for such gauges, which were often rather complicated to make, did not have to be made exactly to specified sizes: so long as their errors were known from detailed measurements, these errors could be compensated for quite simply by adjusting the sizes of the feeler pieces or the zero setting of the various dial-gauges.

Mr. Nickols said that Mr. Hume in his Paper had stressed the advantages of applying the principles of kinematic design to the design of measuring apparatus, and he was sure no one would quarrel with him on that matter. At the risk of appearing heretical in these matters, he would like to draw attention to a development during the past few years in which, in certain applications, radical departures from kinematic principles had been made with complete success. He must hasten to emphasise that these departures were not of general application, but were of great interest in that they showed a completely new approach to the problem of instrument design.

He was referring, he said, to the principle of design which had been termed the "principle of over-constraint and elastic averaging". The principle was perhaps most easily explained by considering as an example of non-kinematic design a horse-drawn flat-bottomed sledge being driven along a rough road. The driver had a rough time, as he was sitting on a hard wooden seat. The sledge-design might be modified on kinematical principles by mounting it on three wheels, and the "ride" or linear displacement of the driver was much improved. A still further improvement might be made by now applying the elastic averaging principle—in this case by inserting a soft cushion between the hard wooden seat and the driver. It would be seen that the main feature of the principle was to recognise the existence of small errors and to absorb them by means of suitably elastic constraints.

As far as he was aware, this novel principle had only been applied in the ruling of diffraction gratings, and the best known example was the Merton nut. This was a pith-lined nut which engaged with a very fine pitched lead-screw about 15,000 t.p.i. Due to the flexibility of the lining, the traverse of the nut was dictated by the average pitch of the leadscrew over the length of nut and the effect of periodic errors of the leadscrew on the accuracy of traverse of the nut was largely eliminated. Obviously, the Merton nut would not compensate for progressive error in the lead-screw but would tend to iron out errors due to periodic errors in the screw.

Mr. Nickols agreed that components should have the largest possible tolerances. A difficulty arose when tolerancing gauges, as the gauge tolerance zone fell inside the component tolerance zone, and the larger the gauge tolerance zone the smaller became the net tolerance left for the component. The magnitude of the gauge tolerance had therefore to be a compromise between ease of manufacturing the gauge and ease of manufacturing the work.

Mr. Hume had mentioned that the proper webbing of large plates prevented flexing. Of course, the moment of inertia of the section was the principal factor which determined rigidity. The advantage of webbing was that it provided stiffness with minimum mass. The plates could have been made more rigid by increasing their thickness—no webbing being provided.

In conclusion, Mr. Nickols referred to the use of large measuring gauges, such as large hand micrometers. For reasons of lightness, the frames of these micrometers were in many cases rather flimsy and when calibrating one of these micrometers on a standard, it was quite usual to get two entirely different results when the micrometer was held with its measuring axis horizontal and vertical respectively. Such micrometers should be used in the same positions as those in which they were calibrated. Also, the use of light alloy frames might lead to undesirable results when measuring steel components, if uniformity of temperature was not maintained.

Mr. Hume, thanking the speakers for their contributions, said that of Mr. Crook needed no answer. The points raised by Mr. Rolt were true enough, but it had taken

him over an hour to read the Paper, and it was a case of having to restrict it to certain aspects. He had, however, extended the Paper somewhat on the lines mentioned by Mr. Rolt. It was his original intention not to mention the design of limit gauges at all, but he realised that something of the kind ought to be brought in.

The main purpose of the Paper was to emphasise that, in the design of ordinary gauging equipment, kinematic or semi-kinematic principles were not yet used to anything like the extent they could be.

The examples he had given of dovetail slides being used for translation, and so on, were a case in point.

The question of receiver gauges and their design, and other more complex gauges, was so wide that he had not touched on it. He was glad Mr. Rolt had raised these points, because they provided food for thought, in addition to the points raised in the Paper.

Mr. Hume did not think Mr. Nickols' remarks called for an answer. Mr. Nickols had added to the information contained in the Paper. The principle of averaging could, no doubt, have a much wider application. It was a little difficult to see where it could be brought into ordinary workshop gauging but, once the principle had been established, ways and means would certainly be found of lightening the burden of workshop measurement. Generally speaking, elasticity was one of the evils one had to fight in gauging. If it could be made to do some useful work, so much the better!

Mr. Watson asked how reliable on fine limits was air gauging in small internal bores.

Mr. Hume said he would not like to go far in expressing an opinion on air gauging. He had only been concerned with it to a limited extent. He thought, however, that its accuracy could be of the order of 0.00005 in. One unfortunate feature about air gauging, as about some other gauges, electronic gauges, for instance, was that one could get very large magnifications. On air gauging equipment it was possible to get 0.0001 in. looking like ½ inch. One was inclined to say that one could split that into ten and measure to 0.00001 in. This might be feasible in some cases but, generally speaking, air gauging had a maximum accuracy of the order of 0.00005 in. It was usually quite good enough in the works to obtain accuracy to 0.0001 in.

Mr. Davidson said that he heartily agreed with Mr. Hume about three-point support. There seemed to be some divergence of opinion between makers as to whether to support things on three points on the floor or to give a huge skirt all round the machine, on which it rested.

The Societé Gènevoise jig borer, the largest model, stood on three points only and there was no deflection at all. But one occasionally came across other makes in which there was a bed of about the same section with multiple pads all the way along. These had all to be levelled up and it was usually an impossibility to the average man to do that.

The principle of averaging had been demonstrated on a grinding machine whose table, when moved along the bed, seemed to be level in various places and did not seem to reflect a twist which was found to be present in the lower bed. The table was obviously gliding along, standing on about three points and generating some sort of surface but would obviously have worn very seriously.

He believed it had been stated that lobing did not occur very often. He had never understood why lathes with roller-bearing headstocks always seemed to give rather more out-of-roundness on jobs than those with plain bearings. He felt that this must be traced back to the lobed rollers produced by centreless grinding.

Mr. Murch said that the gauge tolerances given in the British Standard seemed to vary in some arbitrary way. He had always found it better to take the gauge tolerance as some fixed proportion of the work tolerance; for example, 10 per cent. Could Mr. Hume say why the British Standard departed from that simple proportion and on what basis gauge tolerances were worked out?

Mr. Hume replied that broadly speaking the gauge tolerances *were* 10 per cent., except that a range of work tolerances had been worked out in each case. The figure for the gauge tolerance approximated to the mean of a range of work tolerances.

From the point of view of the B.S.I. and the issue of specifications, the table of tolerances had to be as simple, straightforward and direct as possible so that it could be used by all sorts and conditions of people. As in other specifications, therefore—Limits and Fits, for instance—one had to take a certain range of sizes and give a 10 per cent. gauge tolerance which was somewhere about the mean. That, he thought, was the only reason for any disparity.

For a value at the end of the range, the gauge tolerance would vary slightly from 10 per cent., but at least there was a compact and easily understood table, a table that could be easily referred to and that would presumably become universal.

Mr. Murch said he still thought it would be simpler to take 10 or 20 per cent. and that up to .005 in. work tolerance the gauge tolerance could be 20 per cent. and over .005 in. it could be 10 per cent. He did not think there was any need to standardise gauge tolerances in the same way as limits and tolerances for the work itself.

Mr. Hume pointed out that more errors were likely to arise in the specification of gauge tolerances by this method. One had not only to consider the 10 per cent. but also the direction of the tolerance. Wear allowances were recommended on gauges. In the new gauge specification, where the gauge tolerance was large enough, a certain amount was taken for wear allowance on the gauge.

A gauge tolerance of 20 per cent. would, of course, be too high for a small work tolerance and, in fact, the proportion decreased gradually from 10 per cent. as work tolerances increased. He thought gauge manufacturers would refute the idea that there was not an economic reason for standard gauge tolerances, since they could, to a certain extent, stock standard sizes of gauges.

Mr. Elton said that, with regard to three-point suspension, it was interesting to note that the British Standard for surface tables demanded three-point support up to 6 ft. 4 in. for Grade A surface tables and four-point support above that size.

Mr. Hume said that while he had had part responsibility for some British Standards, including gauges, surface tables and measuring tools, he could not accept responsibility for all of them.

Perhaps he should make it clear—though he did not think anybody needed to be told this—that the British Standard specifications were not perfect. When they first came out they had to be adapted to some extent to existing practice. It was no good issuing an ideal specification for, say, a surface plate over a certain size which would be two feet deep so that there would be no deflection, because no one would make it. The committees had to take account of existing practice. Surface plates of the larger sizes had not been made—and perhaps it was not economical to make them—sufficiently rigid to be supported on a three-point support alone. But to have a larger number of supports necessarily involved jacking or adjustment.

There had recently been some discussion in the B.S.I. committee concerning a demand for surface plates of even greater moment of inertia of section which would provide greater rigidity. Such plates were already in existence. Even for plates only four or five feet square there were suggestions that specially accurate plates for taking heavy loads with precision should be made with greater depth. It was in this way that Standard specifications were developed but they could not go faster than economic practice and the general development of engineering techniques.

(*Continued on page* 343)

DEVELOPMENT IN GEAR-HOBBING MACHINES

by A. K. THOMAS, V.D.I., A.M.I.Prod.E.

Mr. A. K. Thomas

Mr. Thomas has been concerned for more than twenty-five years with the design and manufacture of gears and gear cutting machines.

In 1948 he joined Messrs. Craven Brothers (Manchester) Limited, Stockport, where he now occupies the position of Chief Designer in a Development and Research Office engaged on gearing problems, and the design of hobbing machines for the production of high precision marine turbine gears and ancillary measuring equipment.

MODERN engineering practice is continually increasing its demands for more and more gearing of old and new types with a higher and higher degree of accuracy. It is interesting for a moment to contemplate the variety which has crept into the province of gear-hobbing recently: spur gears, parallel and crossed helical gears, worm gears (worms and worm wheels), internal gears, conical involute gears, spline shafts, chain wheels, certain types of bevel gears, etc. All these gears can be produced on various types of gear hobbing machines yet there are still many components, at present produced by other methods, which could be handled advantageously on the gear hobbing machine.

The distinguishing feature which separates the hobbing machine from other gear cutting machines is that the gear is produced by a simultaneous rotation of both the cutter and the gear being cut. The cutting is continuous and uniform and there is no expensive and complicated intermittent indexing mechanism and no reciprocating cutter. This, while it may not lead to spectacular production times, does ensure that accuracy is not jeopardised by unnecessary mechanism. Furthermore, when cutting helical gears, the slide for the tool is not inclined, as in the case of the gear planer; merely the hob is inclined, but the helix angle of the teeth is governed only by the differential mechanism which imparts an auxiliary rotation to the work table or to the hob. Thus, identical angles for the right and left hand helix are obtained irrespective of the number of teeth.

Again, the performance of the machine and the finish on the teeth are partly dependent on the hob and to this end, the manufacture of the hobs has now become a very specialised industry and hobs of the highest precision are now available. Thus, the hobbing machine, particularly for accurate work, has become firmly established and its development in recent years both in precision and output has been of outstanding importance.

The object of this Paper is to focus attention on these two particular aspects of the subject:-

(1) STEPS FOR INCREASED OUTPUT

(2) STEPS FOR INCREASED ACCURACY.

Steps for Increased Output

Climb Hobbing

When analysing the problems met by the cutting edges of a milling cutter or a hob, it is important to distinguish between the conventional way of cutting and climb cutting.

From Fig. 1 it will be seen that when climb hobbing, the hob rotates as for conventional hobbing, i.e. the teeth cut downwards, but the direction of the feed is upwards, so that the hob "climbs" up along the width of the workpiece. The removal of the comma-like hobbing chips in this process starts at their thick end which is important when hobbing tough materials, i.e. this method serves to raise the hobbing efficiency as the hob cuts material at the very start, and tapers off to the thin end of the chip freely, and rubbing is avoided. Due to this more favourable formation of the chips, the finish of the tooth flanks is usually much better than in the case of conventional hobbing.

From the other part of the illustration it will be seen that in the case of conventional hobbing the chip comma is cut out from the thin end, and first compressed by the tool by rubbing instead of being

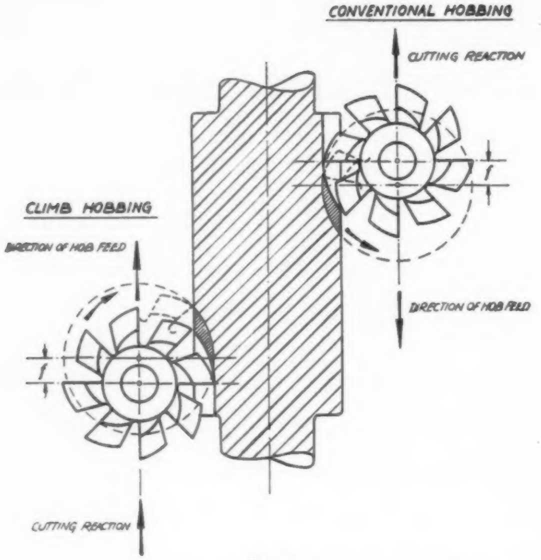


Fig. 1

cut. Consequently the cutting edges of the hob are subjected to much more wear. Further the swarf tends to stick on the hob dulling the cutting edges and spoiling the tooth surface being cut. Therefore, tool life is longer in climb hobbing than in conventional hobbing. The cutting edges are less stressed. The cut is freer and there is less load on the machine.

The essential difference between the two systems is in the distribution of the forces as indicated in Fig. 1. When working the conventional way feed and cutting reaction are of opposite directions. To avoid an irregular motion in upright-type hobbing machines the hob slide must be over-balanced, i.e. it has to be pulled in the direction of the cutting reaction.

In climb hobbing the feed of the hob slide and the cutting reaction are in the same direction. The two reactions together produce a result ensuring smooth running of the machine. However, means have to be provided for taking up the clearance between feed screw and feed screw nut.

The advantages of climb hobbing which may appear together as well as individually, depending on the type of gear teeth, the type of machine and tool being used, and especially the materials to be cut, can be summarised as follows:-

(a) ***Higher cutting speeds,*** e.g.:

140 ft./min. with S 70; 100 to 125 ft./min. with 3 S 15. It will be seen that these speeds are generally 50% to 75% higher than those commonly used in the case of conventional hobbing. As there is no need to reduce the longitudinal feed in relationship to the increase of the cutting speed, the increase of output is approximately 25% to 60% higher than with conventional hobbing. The hob speeds given above are based upon actual experience, but more recent experiments (*) have shown that, under certain conditions, e.g. by choosing a suitable feed, the hob speeds may be increased twice to three times those mentioned.

(b) ***Better finish of the tooth surface,*** especially in the case of tough materials (e.g. S 81), as the swarf is thrown out behind the cutting edges so that the tooth surfaces being cut remain absolutely smooth and matt. Therefore, a climb-hobbed gear is immediately recognised by its matt velvet-like tooth surface, which gives the impression of roughness, compared with the brighter finish of teeth cut conventionally. Unfortunately this appearance is deceptive and has very often led to the condemnation of the climb hobbing method. Actually this dull surface is only due to the natural cutting action when climb hobbing, compared with the compression and friction which occurs at the beginning of the conventional cutting action.

(c) ***Longer life of the cutting edges of the hob,*** which amounts to 20% to 30%, due to the smaller cutting forces and better chip formation. This particular feature is of great importance not only in commercial work but far more so in *turbine gear hobbing*. In this case, large face widths have to be dealt with along which the edges of the hob should remain the same in order to maintain a constant cutting condition from start to finish.

The sharpening time of the hob is reduced which is an added advantage.

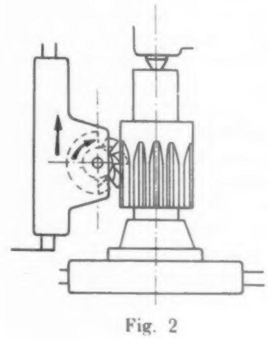


Fig. 2

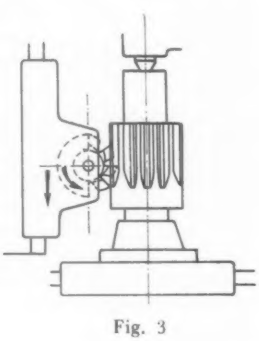


Fig. 3

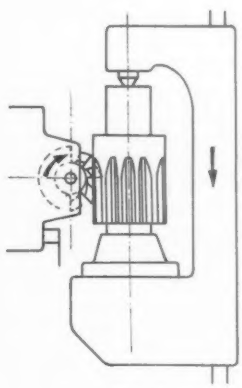


Fig. 4

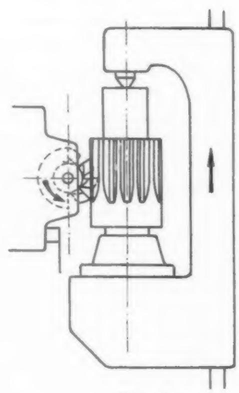


Fig. 5

(*) Machinery, October 16, 1953, Vol. 83.
Machinery, March 6, 1953, Vol. 82.

(d) ***Less burring,*** viz. breaking of the edges on the workpiece when the hob comes through, due to the better cutting conditions.

(e) ***Lower load and quicker running of the machine,*** owing to the freer cutting and higher revolutions, as the torque of the shafts and the tangential loads of the gear drives, etc., are lower.

Whether the accuracy of the teeth, especially the pitch and the tooth form, is influenced by the climb hobbing process it is at present difficult to say. However, there seems to be less hardening distortion of climb-hobbed gears, which may be due to the freer chip removal.

For climb hobbing, generally, a normal hob having radial cutting faces is used. In many cases hobs with a small negative cutting-face angle may be recommended, especially for roughing cuts. Furthermore, a generous amount of cutter lubricant must be available in order to provide the necessary cooling for the cutting edges and to provide the means for a quick removal of the chips from the part of the gear which has already been cut.

As previously mentioned, when climb hobbing the rotation of the hob and the axial feed are in the same direction. Figs 2—5 show in principle the four typical examples. The arrangements most commonly used are represented in Fig. 2, machine of the travelling cutter head type, and in Fig. 4, machine of the travelling work head type. In order to get the full advantage out of the climb hobbing process, the machine should be specially designed for that purpose. The climb hobbing system necessitates a special wear-adjusting arrangement, to eliminate possible oscillations between the feed screw and the feed-screw nut of the hob slide due to the cut tending to pull the work in the direction of the feed. Once this disadvantage has been eliminated, the cut is steadier and proceeds in a smoother way than on the machines of the conventional type.

The most efficient means for this purpose is a hydraulic device, in which case the hob slide is positively pulled hydraulically in the same direction of the feed as the cutting forces impel it. The feed is therefore hydraulic whilst the screw only controls the rate of feed. This eliminates not only the backlash in the feed drive, but also the axial clearance of the thrust bearings of the screw. There are some designs by means of which, during the quick traverse of the hob saddle, the hydraulic pressure can automatically be released to avoid wear.

The oil pressure for the climb hobbing device, varying from 40 lbs. / square inch to 120 lbs. / square inch, depending on the weight of the saddle, etc., is provided by a high-pressure gear pump, which at the same time can also provide the lubrication system of the machine. Furthermore, a hydraulic device has the great advantage that the hobbing machine in question can be used for either climb hobbing or conventional hobbing merely by controlling the oil pressure in the system.

In the case of small machines, the required pressure between hob saddle and feed screw can also be obtained by increasing the size of the balancing weight. However, an alteration of the pressure is obviously more difficult than with the hydraulic system.

An easy way to provide a constant pressure against the thread of the feed screw when climb hobbing, is given by those types of machines which have a vertical moving work table, see Fig. 4.

In this case the heavy work slide moves on the upright past the stationary hobbing head and provides the correct conditions for climb hobbing without any additional attachments. On machines designed with a horizontal work-table axis, the required pressure against the feed-screw thread in order to eliminate backlash, etc., is provided either by a hydraulic device or by mechanical means, such as springs or counter weights, or simply by an adjustable nut designed to take up backlash.

Plunge-Longitudinal Hobbing

When determining the cutting time of a gear, the time the cutter travels along the actual face width must be added to the time for the starting cut or cutter approach. This cutter approach can be done in two different ways, i.e. by the longitudinal method, or by the radial infeed or plunge method.

With the first method, which we might also call the conventional way, the axis of the hob arbor lies above or below the face of the gear by an amount depending on diameters of hob, tooth depth and helix angle in the case of helical gears. The time needed for travelling from the starting cut until the axis of the hob arbor has reached the face of the gear can be a high percentage of the total cutting time, especially in the case of hobs having a big diameter, narrow gears, large tooth depths and large helix angles. Thus, in such cases where a considerable longitudinal cutter approach is needed, it is advantageous to apply the plunge-cut hobbing, viz. radial infeed, and when the full tooth depth is reached then the whole width of the workpiece is finished by using the longitudinal feed. Using this method not only means reduction of the total cutting time, but the formation of chips of uniform thickness during the radial starting cut also eases the work of the machine and the hob.

It should be remembered however, that the radial in-feed should generally be smaller than the longitudinal feed. Depending on the sort of material to be cut, the relationship between radial in-feed and longitudinal feed should be approximately 1 to 2. From this it follows that the advantage in reducing production time can only be obtained when the longitudinal approach of the hob is longer than twice the tooth depth.

In many cases, a radial feed rate representing 75% of the axial feed rate has been found suitable. The range of application of plunge-cut hobbing is indicated graphically in Fig. 6 which shows the relationship between hob diameter, tooth depth and longitudinal approach for spur gears. It is more difficult to determine the length of longitudinal approach in the case of helical gears, as this is governed by the angle at which the hob is set in relation to the gear, which in the case of spur gear

Fig. 7

hobbing can be ignored. A decisive influence, especially on high helix angles, is also exercised by tapering the leading end of the hob. As the diameter of the gear has also to be taken into account, the exact amount of the starting cut can therefore only be found by detailed drawing out of ellipses and conical sections or by trial. Assuming suitable tapered hobs, the approximate longitudinal approach for any helix angle will be given by the starting-cut graph for spur gears (Fig. 6) based, however, on an assumed hob diameter D', which is about 1.35 times as large as the actual diameter of the tapered hob to be used.

In order to get the full benefit from this radial infeed method, the hobbing machine has to be equipped with a special automatic plunge-longitudinal hobbing device. Such a device consists of the actual infeed mechanism (independent from the longitudinal feed drive), which can be a special arrangement of change gears, a variable-speed infeed motor, or a hydraulic system.

The changing over from radial infeed to longitudinal feed has to be done automatically at the moment when the hob has reached the full tooth depth. For this purpose the machine must be equipped with either a mechanical, an electrical or a hydraulically operated clutch which engages the longitudinal feed when the radial infeed stops by means of a precision trip dog in connection with a drop worm, or a hydraulic device.

An automatic locking of the table slide (or column) and overarm (when using a stay) during longitudinal hobbing is easily operated by hydraulic clamping devices (Fig. 7), the oil pressure for which can be supplied from the lubricating pump of the machine.

Automatic Work Cycle Control

A necessity for increased output on hobbing machines for mass production is the automatic control of the work cycle. This applies not only to simple types of gears but even more to complicated work, e.g. identical gears on the same work piece or stacks of workpieces and consecutive operations (roughing and finishing) at one setting. With an automatic control the idling time is reduced and machine, tool and work are ensured against faulty manipulation, damage and waste. The operator only

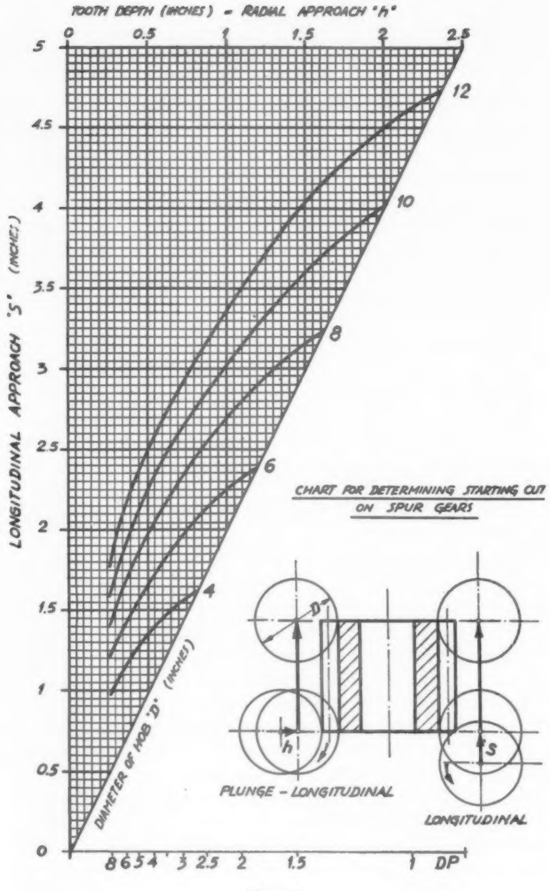


Fig. 6

needs to load and unload the machine, and although the actual hobbing times are shortened the operator can attend to more machines.

The work cycle can be controlled in different ways: hydraulically, electro-hydraulically and fully electrically. The electro-hydraulic system is to be preferred when clamping of the work piece has also to be done automatically. In all the other cases the electrical work cycle control, which can be done by simple electrical means, e.g. limit switches, solenoids or torque motors, etc., or by a so-called "cycle controller", can advantageously be employed. Such a cycle controller operates according to the contour of the workpieces, the sequence of feed and quick power motions of the hob slide and work slide. After one motion, feed or quick traverse is completed, positive stops give an impulse to the control unit to switch-in the next one until the whole cycle is finished. The unit, running on a low voltage (generally 25 volts) can be fixed at any convenient place on the machine. The cycle is decided by inserting plugs through pre-determined holes in a punched card, into a socket field.

Fig. 8 shows the sequence of movements for simple and more complicated cycles, employing the plunge-longitudinal hobbing process. Cycles (a) and (b) can be controlled by simple hydraulic or electrical means. Cycles (c) and (d) are advantageously controlled by an electrical cycle controller.

Means of Eliminating Backlash

In the two most important drives in a gear hobbing machine, which are the hob drive and the work-table drive, it is essential to reduce the backlash between the teeth as far as this is practically possible for the following reason. With excessive backlash in the hob drive, the impacts due to the cutting action of the hob are increased and a jerking motion is directly transferred to the gear train preceding the hob drive. Even with a flywheel, which reduces the transmission of those cutting impacts considerably, inaccuracies, noisy running of the machine and heavy wear of the gears often result.

The same applies to the table drive (master worm drive) having too much backlash. This influences the accuracy of the gears cut and in the case of heavy pitches, a jerking motion is further transmitted to the dividing change gears and the gears preceding them.

Control of backlash, the amount of which must be determined at the " hardest spot " of the gear teeth, can be achieved in several ways. In the case of a hob spindle driven by *cylindrical gears* the following two methods are in use :

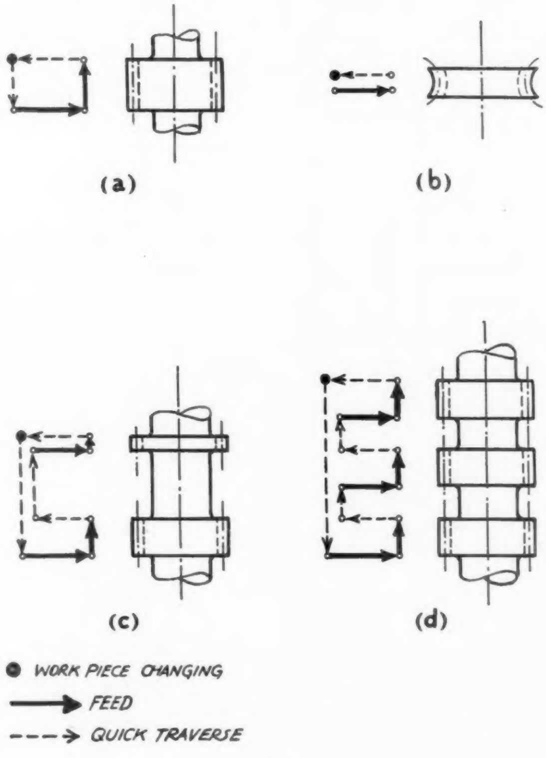


Fig. 8

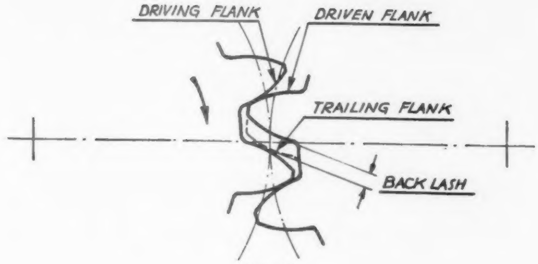


Fig. 9

(1) The driven gear is split into two separate gears. Means are provided (e.g. clamping bolts or loading springs) for imparting relative angular movement to the two gears about their axes to take up any clearance, and for bringing the teeth of each into engagement with the teeth of the driving pinion (Fig. 9). With Universal Hobbing Machines the gear should be split into equal halves, which means that only half of the tooth surface of gear and pinion is loaded for each direction of rotation. However, in such cases where there is no need for swivelling the hob slide about 180°, the gear can be split into two unequal parts with the narrowest portion being used for taking up backlash only.

(2) The driver and driven are designed as so-called " conical involute gears " the teeth of which belong to the involute-tooth system derived from a standard basic-rack profile. Fig. 10 shows that the plane of symmetry ^{P_M} of the profiles of the basic rack ^{Z_B}, however, is not parallel to the axis of the gear as in the case of normal cylindrical gears, but inclined to it at an angle δ. The amount of inclination depends on the utilisation of the gears and is limited by undercut of the teeth at one end and by running to a point at the other. The teeth are produced by the generating process on a hobbing machine, a gear shaper or a gear planer in the usual way, except that the cutter is moved in the direction YY which is inclined at an angle δ instead of being parallel to the axis of the gear, by means of special additional equipment. As the tooth pitch is not influenced by the inclination of the basic rack ^{Z_B}, the pitch plane P and the pitch cylinder W remain unaltered. Thus the contact between this imaginary rack and such a gear takes place along straight lines. Also two conical involute gears connecting parallel axes (Fig. 11 (b)) engage correctly with full line contact. Such gears can be displaced axially without detriment to uniformity of angular velocity, by which means backlash between the gear teeth can be adjusted in a simple way. Fig. 11 (a) shows normal cylindrical gears by way of comparison with conical involute gears.

The formation of the tooth traces *f* may be rectangular (conical involute *spur* gears) or inclined (conical involute *helical* gears) to the direction of

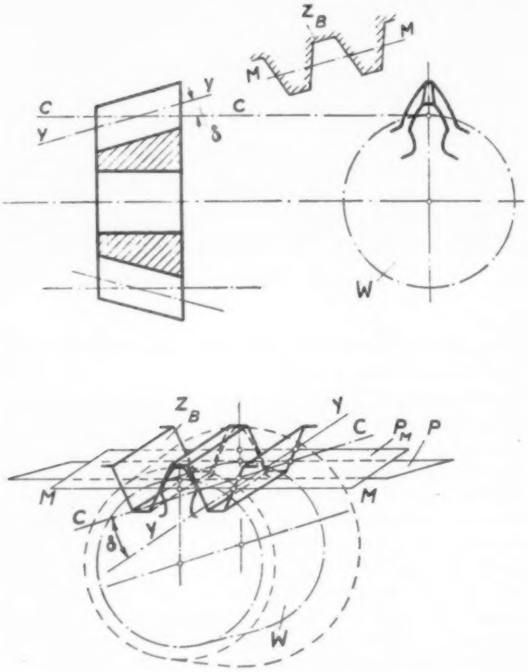


Fig. 10

rolling. In both cases, the pitch circles of engagement $^{d}w1$ and $^{d}w2$ of the mating gears coincide with the pitch circles of generation of the individual gears when in contact with the basic rack.

In *worm gearing*, for either the hob drive or the table drive there are three basically different methods adopted for the eliminating of backlash :

(1) With the conventional and most commonly used method, means are provided to adjust the worm radially until the backlash on the narrowest spot of the worm wheel is taken up. Theoretically speaking this method is wrong, as the worm has correct tooth contact only in that position in which the worm axis coincides with the hob axis during generation. If, however, care is taken that the profile and tooth thickness of the worm is made in accordance with the hob which generated the worm wheel, the amount required for radial adjustment will be extremely small, and if there is no reason to expect noticeable wear after a certain time, this method of radial adjustment may be quite satisfactory in many cases.

(2) In order to eliminate backlash which may appear after a certain running time of the machine, or due to some difference in tooth thickness between hob and worm, very often two worms are employed, viz. a *driving worm* and a *trailing worm*. For taking up backlash the trailing worm is moved axially until contact between the tooth surfaces of worm and wheel occurs. As the centre distance is not altered, a correct tooth engagement is always maintained. Figs. 12/14 show the most commonly used arrangements of the two worms.

Besides this, there is also the possibility of using *one* worm only and splitting the worm wheel centrally into two separate wheels on the plane which contains the diameter of the worm wheel and the axis of the worm. In such an arrangement, only half a tooth surface of the worm wheel is loaded for each direction of rotation. A relative angular movement is imparted to the two half wheels about their axis, to take up backlash by means of springs or just by clamping the two halves together after they have been adjusted.

Another way to eliminate backlash is to split the worm in its transverse plane. Between the two halves a pre-determined adjusting ring is then fixed and the worm is clamped together, or a spring pressure is applied by means of which the two halves are pressed against the wheel teeth. With such a worm drive the pressure angle has to be reduced, in order to compensate for the loss of tooth contact in the middle of the worm.

(3) A simple but very effective solution for eliminating backlash by maintaining correct tooth contact is represented by the "*DUAL-LEAD WORM*" (Figs. 15 and 16). By axially adjusting this type of worm, the backlash is controlled without disturbing the centre distance and without affecting the transmission of uniform motion. Furthermore, the backlash is uniform along the line of action in any adjusted axial position of the worm.

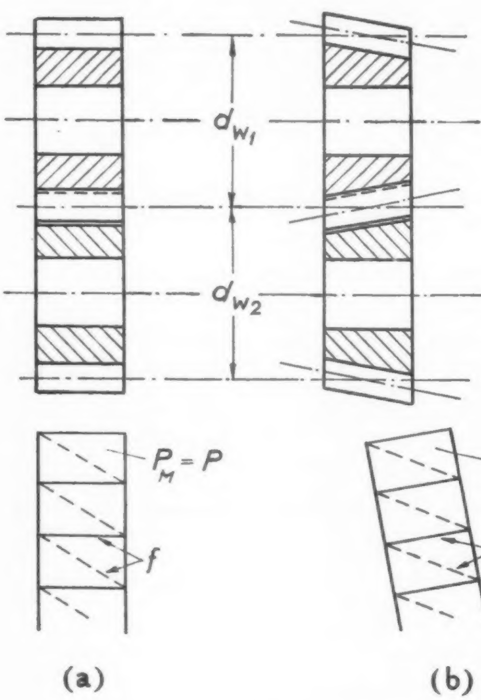


Fig. 11

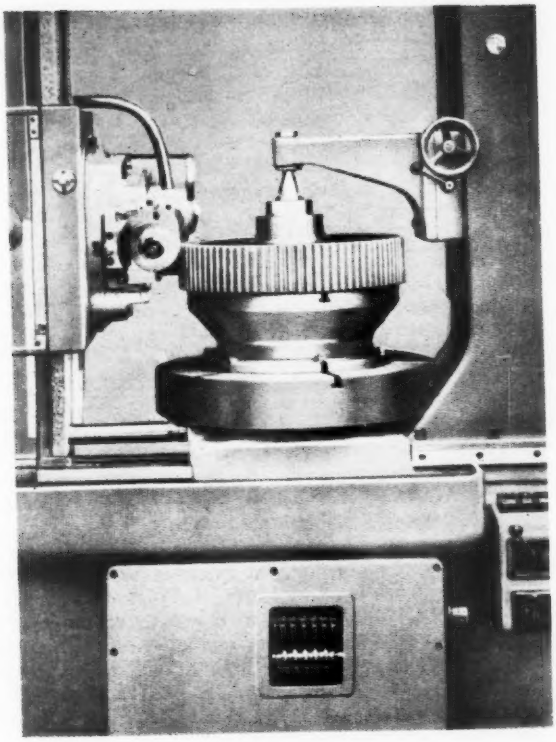


Fig. 12

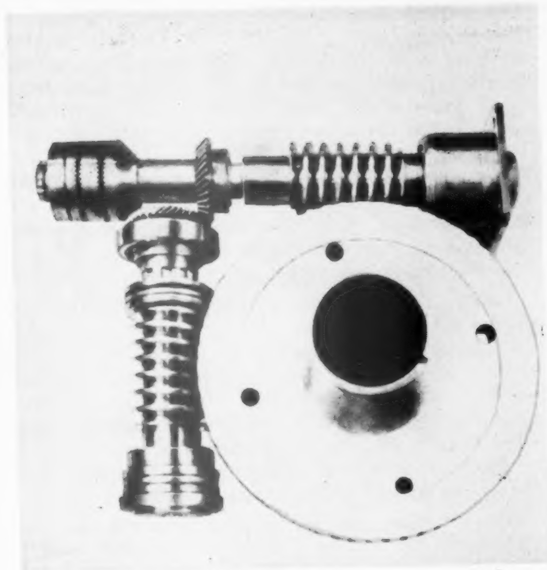


Fig. 13

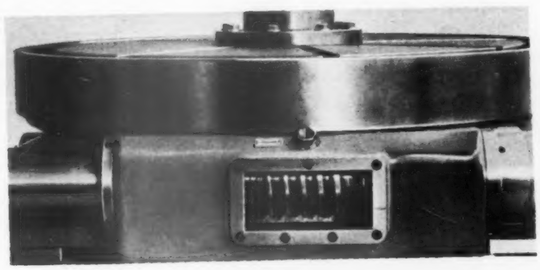


Fig. 15

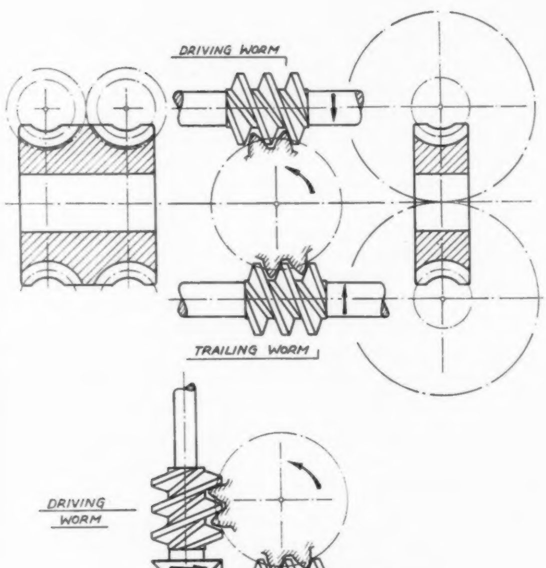


Fig. 14

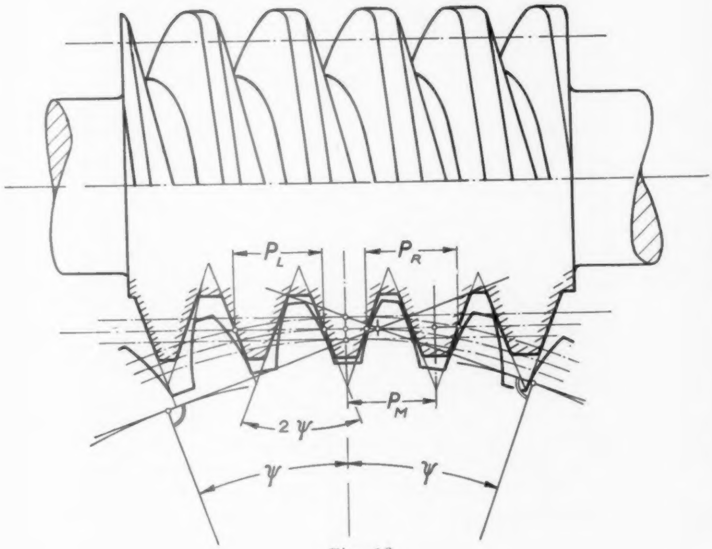


Fig. 16

In theory, the dual-lead worm is a tapered or conical worm having for the right and left flanks a different axial pitch. The difference between the two axial pitches p_r and p_l, or the deviation from the "mean axial pitch" p_m can be determined according to the following guidance rule:

$$p_r - p_m = p_m - p_l = 0.005 \text{ to } 0.010 \; p_m$$

While both sides of the worm thread profile have the same axial pressure angle ψa, the tooth flanks of the worm wheel are unsymmetrical which is due to the fact that each side of the wheel tooth has its own conjugate base circle.

Besides the requirement of minimum backlash in the master-worm gear set, it is of great importance that the accuracy of this drive is maintained. Therefore, in a "high class" hobbing machine the master worm should be in action exclusively for the finishing cut. For roughing or quick rotation of the table when truing the gear blanks for concentricity, it is advisable to drive the table by separate gears, while the actual master worm is taken out of mesh.

This problem can be solved in a simple way by employing *two sets of dual-lead worm drives* (Fig. 17). Here, the one worm used for finishing only has a *fine* pitch while the other worm having a *coarse* pitch, is used for roughing and truing. The short and long leads of the two dual-lead worms are *reversed* relative to each other, and the worms are arranged in such a way that an axial adjustment increases the backlash of the one worm and reduces the backlash of the other. Thus, while the two driving worms are always synchronised, only one at a time makes direct contact with its respective worm wheel.

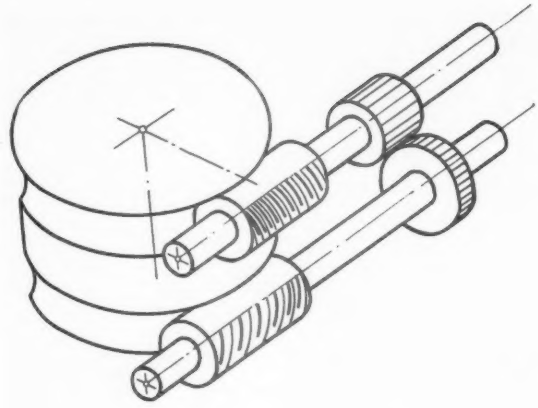


Fig. 17

Hobs

It is generally known that one of the decisive factors limiting the performance of a high-duty hobbing machine is the hob.

A small diameter hob arbor, and in connection with it a hob spindle bearing and supporting bracket far removed from the hob (which is the case when hobbing gears of large diameter), results in deflection of the hob arbor, and consequently, in a chattering cutting action which reduces the life of the cutting edges of the hob, and neither a good finish nor a high degree of accuracy can be obtained. Those troubles which were mostly due to existing hobs with far too small a bore led to the reconsidering of the respective hob standards, with the result that the outside diameters and the bores of hobs are nowadays increased considerably. Another advantage gained by such an increase of hob diameters is that the hob spindle bearing and the supporting bracket can be moved closer to the hob before interference with the workpiece will occur.

Further, an end-slot for driving the hob is recommended rather than a key in the bore. In the case of very heavy cuts the hob spindle and the hob arbor are preferably designed as *one* unit.

Encouraged by the good results obtained with larger hob diameters, some hob manufacturers have developed in recent years non-standard hobs having an enormous outside diameter, and which are known generally as "giant hobs". Such a hob, e.g. for 5 D.P., has an outside diameter of 10", a bore of 3½" and two slots for end-keys. With this hob a longitudinal feed of 0.25" per revolution of the work table and 50 r.p.m. of the hob spindle, have been used when cutting high-tensile steel gears of 10" diameter. This means a considerably increased output. Despite the great longitudinal feed the tooth finish is better than with a standard hob and gears cut in such a way are ready for a post-hobbing process after one cut, as due to the large diameter of the hob an overlapping of the feed troughs, or a smoothing out of the tooth surface respectively, takes place. The chart in Fig. 18 shows the heights and the troughs relative to the feed and the hob diameter. For the example mentioned above, i.e. feed=0.25", hob dia. 10", the high points between the troughs are approx. 0.0016", while the roughness or undulation along the tooth surface is only about 0.0005" with 20° P.A. Appreciably greater outputs, especially when rough hobbing, may result from the use of multi-start hobs, which means higher speeds of the work table when using the same hob speed as for the single-start hob. Besides this, higher rates of feeds are permissible due to the more favourable cutting action of such hobs, as compared with a single-start hob.

However, the increase in output is not in proportion to the number of starts in the hob. In practice the increase obtainable is approx. 60% for a two-start hob, and approx. 100% for a three-start hob.

High-Speed Hobbing

Another way to increase the output of a hobbing machine is to speed up the revolutions of the hob spindle. It is generally known that at speeds immediately higher than those used in conventional practice, a shorter hob life is to be expected. But big-scale experiments with hobbing steel gears having a Brinell hardness of 125 to 375 have shown that

hob life between regrinds can in many cases be greatly increased, and production time reduced, by increasing hob speeds and feeds beyond that point at which tool life had hitherto been believed to be at its lowest figure. By altering both the speed and the feed, in some cases an increase in hob life of 50% to 70% has been obtained while using cutting speeds as high as 350 feet per minute, and feeds per revolution of the work table in the order of 0.115" for roughing and 0.040" for finishing.

In connection with such research work it is interesting to know that tests are now carried out with hob speeds up to 600 ft./min. This means that the hob spindle must be capable of running for long periods with more than 750 r.p.m. Those speeds far in excess of today's gear cutting practice require specially designed hobbing machines, i.e. to meet the conditions in high-speed hobbing the machine must be rigid not only in the structural elements, but also in the operating units. All the gear shafts, including the hob spindle and the master worm, must be mounted in high-precision roller or ball bearings specially selected to ensure trouble-free running under these conditions.

The maximum speed at which gears can be hobbed does not only depend on the ability of the machine to withstand indefinitely the stresses imposed by the higher speeds and the greater power which must be transmitted at those speeds, but also upon the design and the quality of the hob.

Hobs with *inserted blades* of special high-speed steel, e.g. 12½% tungsten and 3 to 5% cobalt, depending upon the work for which the hob is required, have been operating at speeds up to 330 ft./min., and feeds up to 0.050" per revolution of the work table.

Further, *carbide-tipped* hobs offer the possibility of using ultra-high speeds, and hobbing machines with hob speeds up to 1,000 r.p.m., and designed to meet the special requirements of such a tool (if available!), are already made.

Hobbing Heads

The present trend of development in cutting heads shows a more rigid design of the hob spindle, its bearings and its drive.

As pointed out in the section on hobs, the hob arbor and the hob spindle are preferably to be made as one unit. The main bearings are pre-loaded precision roller bearings which have the advantage of running practically without any clearance, of avoiding local heat development near to the hob which might influence the accuracy of the gear being cut especially in the case of high-speed hobbing precision gears, and of being situated closer to the hob. The drive to the hob must be able to absorb the cutting impacts, viz., no chatter or vibration from the hob under heavy cuts, should be transmitted to the machine.

For this reason a worm drive in conjunction with a fly wheel is adopted, and special means are provided to take up backlash (see section on "Means of Eliminating Backlash").

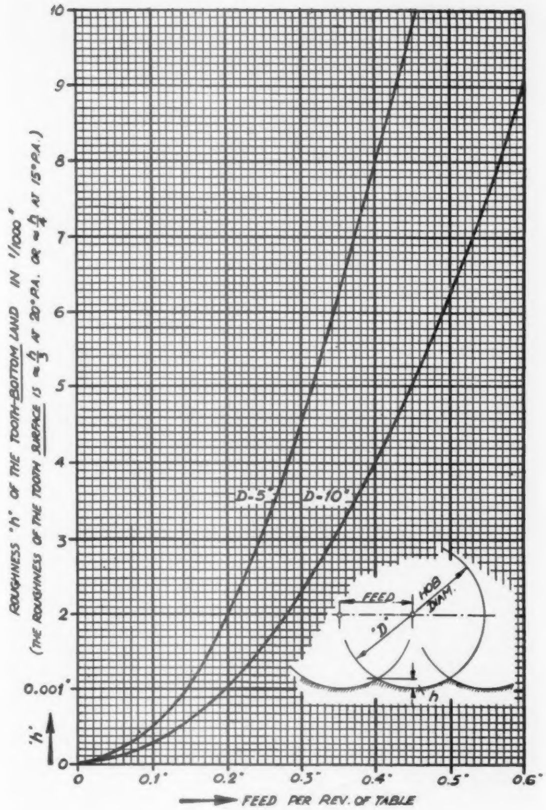


Fig. 18

Besides those most important developments in hobbing heads mentioned above, there are more new features which add to the improvements in performance and output. One of them is the *Automatic Hob Shifting Mechanism*, which moves the hob axially by an adjustable amount after a pre-selected number of work cycles. By this device, all teeth of the hob enter successively into action and uniform wear of the cutting edges along the whole length of the hob takes place. In some designs the hob traverses continuously along its axis during the cut, thus distributing the wear uniformly on all the teeth on the hob. This axial hob traverse provides also a means of hobbing tapered spline shafts by using a tapered hob. Further, the lubrication of the hobbing head needs more consideration, especially worm-driven hobbing heads, in which case the lubrication has also to fulfil the purpose of cooling.

For this reason it is advisable to connect the hobbing head of the traversing type with the main lubrication system by means of flexible or telescopic tubes, in order to provide the head continuously with fresh (cooled) oil. In the case of worm-driven high-speed hobbing heads, it is also advantageous to increase the radiating surface (air cooling) by providing the worm-drive housing with cooling fins, or to incorporate an electrical fan.

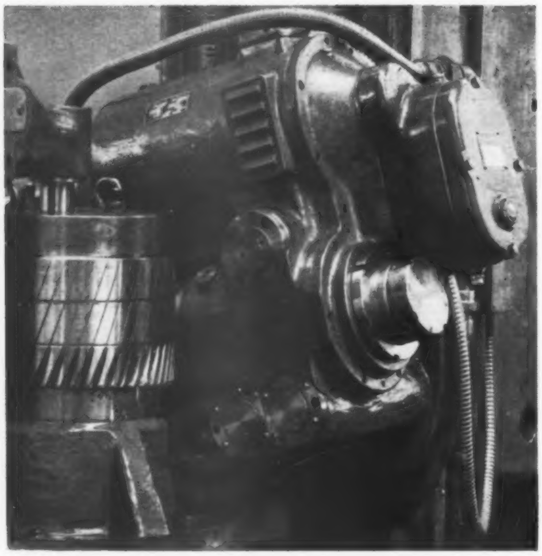


Fig. 19

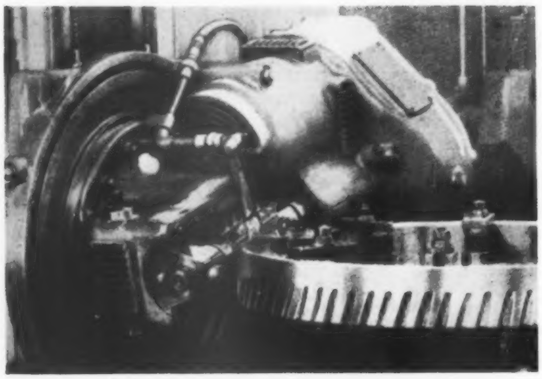


Fig. 20

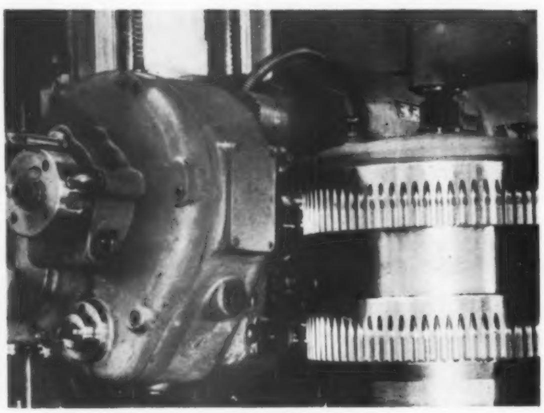


Fig. 21

A step further in the direction of increasing the rigidity of the hob drive is made with the *Motorised Hobbing Heads,* Figs. 19/21. With such an arrangement, the main drive (usually placed at the far end of the machine) is moved towards the hobbing head and is consequently very close to the hob itself. The result is a very short and rigid gear train from the main drive motor to the hob spindle. The change of hob speed is controlled by pick-off gears, or automatically operated change gears mounted in the hobbing head. With the constant fly wheel effect of the rotor, an optimum of damping the chatter caused by the hob is obtained and the following gear train, obtaining its drive from the hobbing head, is practically free from torsional vibrations, and the machine consequently runs more uniformly.

Finally, the advantages of a driving motor directly mounted on the hob saddle can be stated thus:-

Increased output by being able to allow higher cutting speeds;

Improved tooth finish of gears being cut;

Longer life of the hob;

Quieter performance of the machine and greater accuracy, and longer life of the gears involved.

Hob Coolant

The experience that a copious supply of cutting lubricant increases hob life and improves work finish has led to a further development of the existing hob cooling systems. There is, for instance, the arrangement of a double nozzle, mounted above and below the hob (Fig. 22). Furthermore, large-capacity gear pumps, e.g. approximately 30 gallons per minute for heavy-duty hobbing machines of medium size, deliver the coolant from a special tank, provided with a cooling system, or of such a size that the returning coolant has sufficient time to cool down before being returned to the hob.

To prevent the splashing around of the coolant, special sheet metal covers (if possible with perspex windows) and chutes for leading the coolant back into the tank, have to be provided around the table. Besides this, automatic turning on and off of the coolant should be included in the case of machines with automatic work cycle control. While the rise of temperature of the coolant after eight working hours is approximately 60°F. with standard coolant equipment, this amount can be reduced by more than a half when using a much more copious supply.

Obviously, a generous supply of coolant having a low temperature helps to increase the life of the hob. Consequently large-scale experiments have been carried out for the purpose of ascertaining the output of hobbing machines and the life of hobs by "low temperature cooling" the cutting edges of the hob. For this purpose a specially designed refrigeration system cools the hob lubricant, which returns from the hob with a temperature of approximately 41°F., down to approximately 14°F.

As, however, under the most favourable conditions an increase of not more than 25% of hob life may be expected by a "low temperature cooling", such rather expensive and elaborate equipment fulfils its

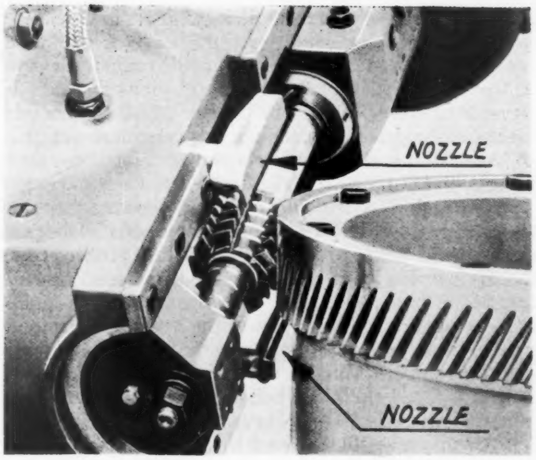


Fig. 22

purpose only in the case of high-duty mass production, where a hob should stand at least one shift before re-sharpening.

Additional Equipment

(1) *Hobbing Device for Conical Involute Gears*

In Universal Gear Hobbing Machines the radial infeed is generally governed by the "normal" feed change gears, i.e. only one of the feeds can be used at the time.

When cutting conical involute gears, however, both the radial infeed and the longitudinal feed are required simultaneously. While the hob travels along the face width, the work table moves towards the hob (or *vice versa*), thus producing a conical gear. By introducing a special set of change gears which govern the radial infeed in relation to the longitudinal feed, the required cone pitch angle can be obtained. As described in the section, "Means of Eliminating Backlash", conical gears cut in such a way have a true involute tooth form. With parallel shafts they engage correctly. As bevel gears they represent a suitable substitute in such cases where the cone pitch angle is too small or the cone distance too great to be cut on a bevel gear cutting machine.

Instead of using special change gears, the radial motion of the work saddle can also be cam-controlled. With such a device any outside shape of the gear can be described, e.g. spherical gears for tooth clutches.

(2) *Worm Cutting*

On hobbing machines provided with a tangential hobbing head for cutting worm wheels by means of a hob or a fly cutter, worm threads of small lead angle may also be cut economically, using as a tool a pinion-type cutter.

The worm to be cut takes the place of the hob whilst the cutter is mounted in place of the workpiece (Fig. 23). During the rotary motion of the cutter and the worm, which rotate relatively in the ratio of the number of starts of the worm and

Fig. 23

the number of teeth in the cutter, a tangential feed motion of the hob slide takes place. To compensate for this feed motion of the worm, the cutter obtains an equal auxiliary rotation by the differential mechanism.

(3) *Multiple Work Spindles*

In cutting large quantities of small gears, the output of a standard hobbing machine can be increased considerably by fixing above the worktable an additional multiple work-spindle arrangement as

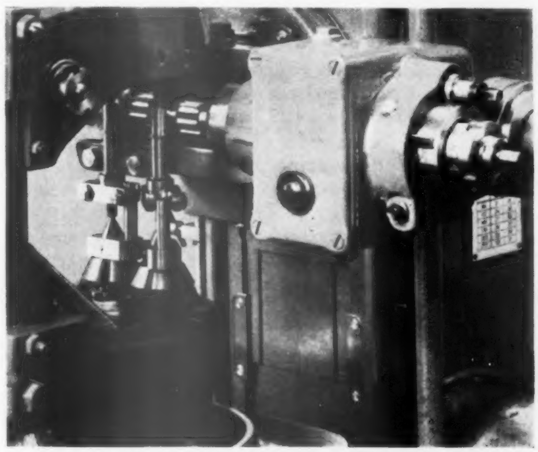


Fig. 24

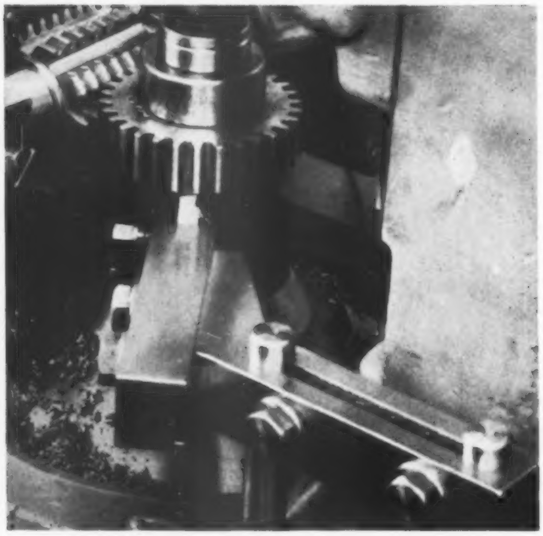


Fig. 25

shown in Fig. 24. Such a device, mounted on the stay, is driven by a gear which is connected with the original work table. The hobs to be used must be absolutely equal in both the outside diameter and the tooth profile.

(4) *De-burring Attachment*

At the end-face of the gear blank where the hob runs out, a certain amount of burr will be caused, depending on the kind of material being cut. Generally this burr has to be removed in a special process, either by hand or by means of speciallv designed machines.

For mass production, satisfactory de-burring of the teeth of gears after cutting therefore often presents a difficult problem. However, the time needed for de-burring can be reduced considerably by attaching a simple trimming device to the hobbing machine itself, as shown in Fig. 25. With such an attachment the burr is removed automatically from the lowest mounted workpiece during the hobbing process. Thus there is no need for any re-mounting of the work-piece and consequently it will help to increase the output as there is, generally speaking, no further time for trimming required. This auxiliary trimming attachment, fitted against the stay, is adjustable in respect of the different gear diameters and heights from the work table. The adjustable tool-holder carries the de-burring tool which must be set against the face of the gear blank before cutting starts, in such a way that the burr is removed when the work-piece rotates. The tool itself is pushed against the face of the gear blank by means of spring pressure which can be adjusted in accordance with the material to be cut.

(5) *Electronic Control*

Speed and feed of the hob must be varied according to the cutting conditions. For varying the speed of the hob, generally pick-off gears or a change gear box are employed. In the case of the feed motion on most machines of conventional design, a feed box with change gears or pick-off gears is provided. Now, however, it is a trend in modern machine design to replace such mechanical controls of speeds by electronic controlled variable-speed motors.

With such a system the principal advantages are: simpler gear layout of the machine; no elaborate changing of gears to suit the respective cutting conditions; stepless controlling of speed and feed just by turning a knob, changing over from feed to quick traverse means only increasing the speed of the feed motor, thus there is no changing or locking of levers; feed adjustment during operation of the machine (reduced feed when the hob begins to bite into the material, increased feed where the hob cuts into the full depth); reversing of feed by simple manipulation of a button; possibility of automatic work cycle, in which case it must be possible to adjust speed and feed automatically during cutting operation; both longitudinal and radial feed motions are controlled in the same way.

Without any doubt such an electronic controlling system represents an important feature in new designs

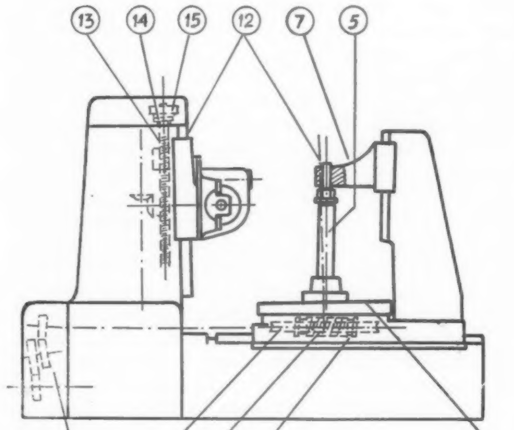


Fig. 26

of hobbing machines; but the higher costs and complicated electrical circuits must be set against the expected production.

(6) *Production Time Saving Features*

Delayed-action device for disengaging the feed and stopping the machine. This feature is of great importance when hobbing large quantities of worm wheels, or spline shafts on which the hob cannot cut out freely. After reaching the required cutting depth the feed is disengaged, but the work makes at least one more revolution in order to obtain an equal depth of all the teeth.

Measuring device directly mounted on the machine for testing the teeth being cut, without removing the gear from the machine, and for checking concentricity of the work when setting. The time for setting large turbine reduction gears can be reduced considerably by applying an optical truing device for checking the concentricity of the lower journal.

Automatic loading devices, mainly hydraulically operated. The operator only needs to change the work. In spite of shortened hobbing times, he can attend to more machines than hitherto.

Lead cam (helical guide) directly mounted on the work spindle, instead of spiralling change gears. It controls the lead when cutting helical gears on machines for mass production.

Quick traverse of table by disengaged master worm, especially on large hobbing machines for high-class work. To ensure the accuracy of the machine when running on a higher speed for setting the work-piece, the master worm is disengaged and the table is driven independently from the further gear train in the machine.

Steps for Increased Accuracy

Fundamentals

Before considering the development and the improvements which have been made in recent years in respect of increased accuracy of hobbing machines and, in consequence, the improvement of the quality of hobbed gears, a comprehensive summary of the possible sources of errors in a hobbing machine should first be considered.

Fig. 26 shows the " Error Diagram " of a hobbing machine in which the inaccuracies are very much exaggerated in order to obtain a picture easy to survey. The possibilities of errors and their results are summed up in the chart shown in Fig. 27.

Means for Reducing or Avoiding the Errors Specified

In order to attain the degree of accuracy necessary for high-quality gears, a modern gear hobbing machine must work to close tolerances, usually of the order of 0.0001″ to 0.0004″, according to the dimension measured. A considerable amount of work has been done on improving the accuracy of hobbing machines for high-class work, and proper standards of accuracy for these machine tools have been published, e.g. in Great Britain: B.S.S. 1498: 1948, and in Germany: DIN 8642. With that, standards of accuracy are established in respect of the master worm gearing, feed screw, intermediate gears, table motion, hob saddle motion, eccentricity of rotation and axial float of hob spindle, eccentricity of rotation of table, etc., and as one of the most important items: the *alignment* of the machine.

Besides the permissible errors and tolerances in gear hobbing machines, in respect of the standard publications mentioned above, there are, however, other means for improving accuracy, and some of these are given in the following summary. The numbers 1 to 15 refer to those of the chart in Fig. 27.

1. Long-guided thrust collars, as close as possible to the hob to eliminate the influence of differences in temperature.
   Radial and axial bearing clearance adjusted independently from each other.
   Bearings sealed completely to avoid penetration of dust, etc., which could destroy the accuracy of the bearing surfaces.

2. Hob arbor and hob spindle have to be designed as one unit.
   Hob driven by end-keys only.
   Minimum of clearance between hob and arbor.
   Use of " *expanding mandrels* ", which are cent-trally expanded by means of oil pressure, plastic material or mechanical means. With such an arbor (or hob spindle) the hob can easily be mounted and the necessary clearance needed for it is taken up completely by expanding the arbor uniformly.
   For lower or medium hob speeds the hob spindle, having a shrunk-on bronze bush, rotates in a hardened steel bearing bush in order to avoid local wear.
   For higher hob speeds the use of high precision pre-loaded roller bearings for the hob spindle is recommended, in order to reduce the necessary radial clearance of the bearing to a minimum without risk of seizure, which would be the case with plain bearings where any rise of tempera-ture due to higher surface speeds tends to diminish the clearance.

3. Hob-spindle bearing and supporting bracket (tail bracket) machined independently as a cylinder and fitted into a semi-circular trough.
   Hob arbor of increased diameter.

4. Inspection of all the intermediate gears before mounting.

5. and 6. Table surface and bore for work-arbor bush machined finally in position.

7. Routine check of alignment, etc., at regular intervals, or continuously recording errors in the

No.	*Main Group*	*Nature of Error*	*Results of the Errors in the Gears being hobbed*
1	Hob Slide	Axial float per revolution of the hob spindle.	Tooth-form error of the full amount.
2		Eccentricity or wobble of hob-arbor or hob.	Partly as tooth-form error.
3		Misalignment of support bracket (imparts deflection to the hob-arbor).	Partly as tooth-form error.
4		Inaccurate or eccentric gears (cyclic errors of worm) driving the hob including the gear train leading to it.	Partly (small amount only) as tooth-form error.
5	Table and Stay-Bracket	Eccentricity or wobble of work arbor, (which might also be bent due to misalignment or non-squareness of mounting surfaces).	Eccentricity of the full amount.
6		Table is not square and flat.	Errors in tooth spiral.
7		Misalignment of stay-bracket due to wrong distance or non-parallelism of the guides on the stay in respect to the work arbor, (results in deflection of the work arbor).	Eccentricity.
8		Inaccurate or inexactly mounted master gear, (eccentric or distorted).	Pitch error and tooth-form error (the latter especially in the case of a small number of teeth in the gear being cut) in the ratio: $\frac{\text{Diameter of gear being cut}}{\text{Diameter of master gear}}$
9		Inaccurate or inexactly mounted (eccentric) master worm.	Tooth-form error in the ratio: $\frac{\text{Diameter of gear being cut}}{\text{Diameter of master gear}}$
10		Axial movement of master worm.	Tooth-form error in the ratio: $\frac{\text{Diameter of gear being cut}}{\text{Diameter of master gear}}$
11		Inaccurate or inexactly mounted dividing change gears including gear train leading to them.	Partly tooth-form error in the ratio: $\frac{\text{Diameter of gear being cut}}{\text{Diameter of master gear} \times T}$ T=Number of teeth in master gear.
12	Guides for the hob saddle	Non-parallelism between guides for the hob saddle and work arbor, or non-squareness between guides for the hob saddle and table surface.	Errors in tooth spiral and in tooth thickness.
13	Feed drive (when hobbing helical gears).	Pitch errors in the lead screw.	Errors in tooth spiral.
14		Axial movement of the lead screw or its nut.	Errors in tooth form and tooth spirals, depending on tooth inclination.
15		Inaccurate or inexactly mounted gears for the feed drive.	As 14, but reduced in relationship to the lead screw.

Fig. 27

alignment of the hob slide relative to the axis of rotation of the table.
Built-in spirit levels, mainly in the case of large machines.
Rigid connection between stay and column to avoid deflection during cutting.

8. Master gear to be cut finally when mounted on table.
Means for radial adjustment of table spindle to compensate for any eccentricity introduced by the master-gear hobbing machine.
An important requirement is that the work table shall rotate truly about a fixed axis and shall not be free to float laterally by more than a fraction of a thousandth of an inch.
Coarse- and fine-pitch master gear, the first one for setting and roughing and the latter for the finishing cut of high-precision gears.

9. and 10. Long-guided thrust collars.
Routine check of true running at regular intervals.

11. Change gears with tapered or splined bore.
Inspection of all intermediate gears before mounting.

12. See 7.
Deep reinforced concrete foundation in order to maintain the alignment of the machine.

13. Coarse- and fine-pitch lead screw, the first one for setting and roughing, the latter for the final cut of high-precision gears.
Corrector bar arrangement along the guide of the hob saddle to compensate for progressive errors in the lead screw.

14. Long-guided thrust collars.

15. See 11.
Additional features, especially on large high-class gear hobbing machines, e.g. turbine-gear hobbing machines :
Thermo-electrical temperature registration of the main bearings, the lubrication oil and the cutter lubricant.
Lubrication oil and cutter lubricant (water)—cooled.
Hydraulic or mechanical relief of the weight of the work table, including workpiece and supports, in order to reduce the torsional stresses imposed on the gears and shafts leading up to the table drive. In the case of high-precision hobbing machines these torsional stresses can be further reduced by employing a torque motor synchronised with the main drive motor, and driving the master worm directly.
For similar reasons such a weight relieving device should be applied to the moving column of vertical machines and to the hob saddle of horizontal machines (pinion hobbing machines).

FUNDAMENTALS OF GAUGE DESIGN—DISCUSSION (*continued from page* 328)

Mr. R. Kirchner said he was very glad to hear Mr. Crook's simple description of grinding the taper from the end to the "Not Go" end of the gauge, to give an indication of how far the operator had reached. In principle, that was worth bearing in mind.

The tendency over the last half-century, or for as long as there had been gauges, was to tell people when they were wrong. He could not help feeling tonight that there was a tendency to "go scientific" and perfect ways and means of telling the other chap when he was wrong. It would be a very good idea, from the gauging point of view, to try to tell him before he had gone wrong.

Mr. Crook's example of the taper on the plug gauge was very simple. There were grinding machines with built-in gauging devices where the operator could see what he was doing. There had been a very fine example of a lathe development where there was an optical device which permitted the operator to see what he was doing and when he had arrived at the point where he ought to stop.

He knew it had no bearing on the Paper, but he felt himself that it was along these lines that the people concerned should concentrate their energy. Let them tell people before they went wrong and the job had to be scrapped, rather than become scientific about it afterwards.

Mr. Hume said he thoroughly agreed with Mr. Kirchner that the aim of gauging measurement should be to check the job before it went wrong. Anything he had said in his Paper, it was fair to say, could be applied in that way as well as to final inspection. In fact, the indicating type of gauge enabled the operator to take a measurement before he finished to size; it was doing the same as Mr. Crook's taper gauge.

It was in that type of gauge particularly that kinematic and semi-kinematic principles in design became so important. One could not very well design a kinematic plug or gap gauge, but in a measuring device, whether a receiving fixture, a gauge device on the machine or a comparator device beside the machine or applied to the job, one could employ these accurate slides, locations, cross-strip pivots, conical pivots and so on to the great advantage of the operator. It was in the intelligent use of these things that one was able to bring the measurement where it was wanted.

Inspection should come into the shop, on the shop floor. Everyone was now familiar with a principle that went even further. One did not point out where a thing was wrong as it was being made. One could tell it would be wrong *before* it was made, by means of statistical quality control. It was a question of abstract science, the science of pure mathematics, doing a really first-class practical job. It could be done with a little practice and training on the part of the people concerned in a way that they could all understand and appreciate.

BRITISH STANDARDS

The following Standards have recently been issued and may be obtained, post free, at the prices stated, from the British Standards Institution, British Standards House, 2, Park Street, London, W.1 :—

B.S.2079 : 1954.	Steam Receivers and Separators	(12/6).
B.S.2466 : 1954.	Black Taper Washers	(2/-).
B.S.2452 : 1954.	High Pedestal or portal jib cranes	(7/6).

MAXIMUM EX MINIMO

by E. G. BRISCH, Dipl.Ing., M.I.Mech.E., M.I.Prod.E.,

Managing Director, E. G. Brisch & Partners, Ltd.

AN urgent order is held up for want of a single part. Are you certain there is not an alternative item in the stores which can be used to replace it? You cannot be, unless you have a quick and simple means of identifying and locating it. But have you such means?

When a new product is being designed, are you able to make the maximum use of existing detail parts and their tools irrespective of the product for which they were previously designed? Experience has shown that while this is often possible, it is very rarely done, simply because there is no easy and rapid means of locating past drawings, to establish whether already designed parts can be utilised in new designs, or whether, if a new part must be designed, it can replace an existing one.

When a new component is to be put into production, is any attempt made to utilise the tools previously manufactured for similar items? Again, unless there exists a simple and rapid method of locating these tools and their drawings, they remain out of use, although in many cases apparently obsolete or disused tools can be brought back into production, with slight modification if necessary, at a much lower cost than that of producing new ones.

Are your stocks too high and have you the means to reduce the variety held and to increase the rate of stock turnover?

Is your service organisation able to offer quickly and without error alternative substitutes where the spares requested are not in stock?

If the answer to any one of these questions is "No", it can only mean that your classification service does not give you what it should. My experience over more than twenty-five years of practice has shown that classification can solve all these problems providing that it is scientifically designed, technologically correct, and simple to use.

Some form of classification always exists, but it is usually prepared by personnel who lack specialised knowledge and experience, and, consequently, benefits, which would otherwise be achieved, are, in fact, not obtained.

As in the case of all special problems, industrial classification should be entrusted to specialists, who confine themselves to this—admittedly very narrow—field alone. It must be more than just an inventory. It must provide a permanent means of comparison of what a firm *has* with what it *needs* and so bring to light everything superfluous. Simplification, i.e. the deliberate reduction of *unnecessary* variety, leads the way to increased productivity. The control of the *necessary* variety guides the policy of standardisation.

The Aims of Classification

Every system of classification must:

1. make it possible to find an existing item or to ascertain that a particular item does not exist;
2. find all the items capable of satisfying a given need;
3. find all the needs which a given item can satisfy;
4. ensure that there is one place, and one place only, for all existing items and future additions.

These aims are clearly extremely difficult to achieve, so that the method applied must be technically sound and the result completely foolproof. Only then will it be found whether the presence of certain items is justified, whether duplications exist, whether materials are redundant and whether stocks are idle or slow moving. If the existing classification is not capable of revealing duplications and redundancies, then it is falling short of its essential function. Varieties will increase to no useful purpose, stocks will rise and further capital be tied up. It is the function of classification to bring these anomalies to light and to localise them; to eliminate superfluous variety and control essential variety; to release capital and to prevent wasteful dissipation of the firm's assets.

To many, classification and coding appears as a low grade job of grouping similar items and allocating numbers and letters—more often than not meaningless. To others, it signifies more paper work. But, to enlightened Management, classification has

come to be regarded as an organisational service as much as any other management technique. It must be dynamic and not static and, providing it is purposefully designed and technologically sound, it will:—

1. constitute a revealing description of all the firm's holdings—materials, stores, products, plant;
2. help to make use of forgotten items;
3. bring to light everything that is not indispensable, with a view to its elimination;
4. facilitate the creation of something new utilising as many existing items as possible.

The Cost of Faulty Classification

Employees seeking to bring order and clarity into their firms often create systems of classification without having the essential specialised knowledge. They fall into the trap of regarding such work as an end in itself, rather than the means, and consequently classify for the sake of classifying, achieving only deceptive orderliness. Such systems, including those purporting to be universal, fail to prevent the increase of needless variety in the future, let alone eliminate that which accrued in the past, and often conceal the true identities of items classified.

Codes usually consist of figures and letters. Sometimes dimensional features are also included. These are often arranged without any logical order. Quite frequently, the codes consist of a variable number of digits. Such codes fail, either because they do not allow for expansion, or because they become unintelligible. The classifications expressed by such codes are, from their inception, obviously doomed to become inefficient tools. Does a progressive firm retain a useless or out of date machine when a new and more productive machine is available, the cost of which can be recovered in a reasonably short time?

Classification by the Specialist

The prospective owner of a new car is not interested in the steel alloys used in the steering column, nor in the structure of the brake mechanism. He relies upon the manufacturer to resolve these mechanical points. But he is concerned with the petrol consumption, ease of maintenance and handling, simplicity to drive, comfort and colour. These might be termed his " car specification " which the car manufacturer—the specialist—fulfils for him.

Similarly, specialists in industrial and commercial classification and coding meet the specific individual requirements of each particular organisation. While the principles of classification and coding are universally applicable, the techniques now developed enable any industrial concern to

MANUFACTURE THE MAXIMUM VARIETY OF PRODUCTS OUT OF THE MINIMUM VARIETY OF COMPONENT PARTS USING THE MINIMUM VARIETY OF PRIMARY MATERIALS AND TOOLS.

This is considered to be essential, and can only be achieved by systematical classification, of which the coding is the symbolic expression. There are important technical and practical reasons why purely numerical codes should be used, consisting of a carefully selected number of digits. Once their number has been adopted, normally seven or eight digits, the length of the code should remain constant throughout.

The " Brisch " Method described

The lines of thought leading to certain well defined methods of Classification and Coding resulted in establishing two vital and fundamental principles without which the " Ex Minimo Maximum " philosophy could not become a reality. These are:

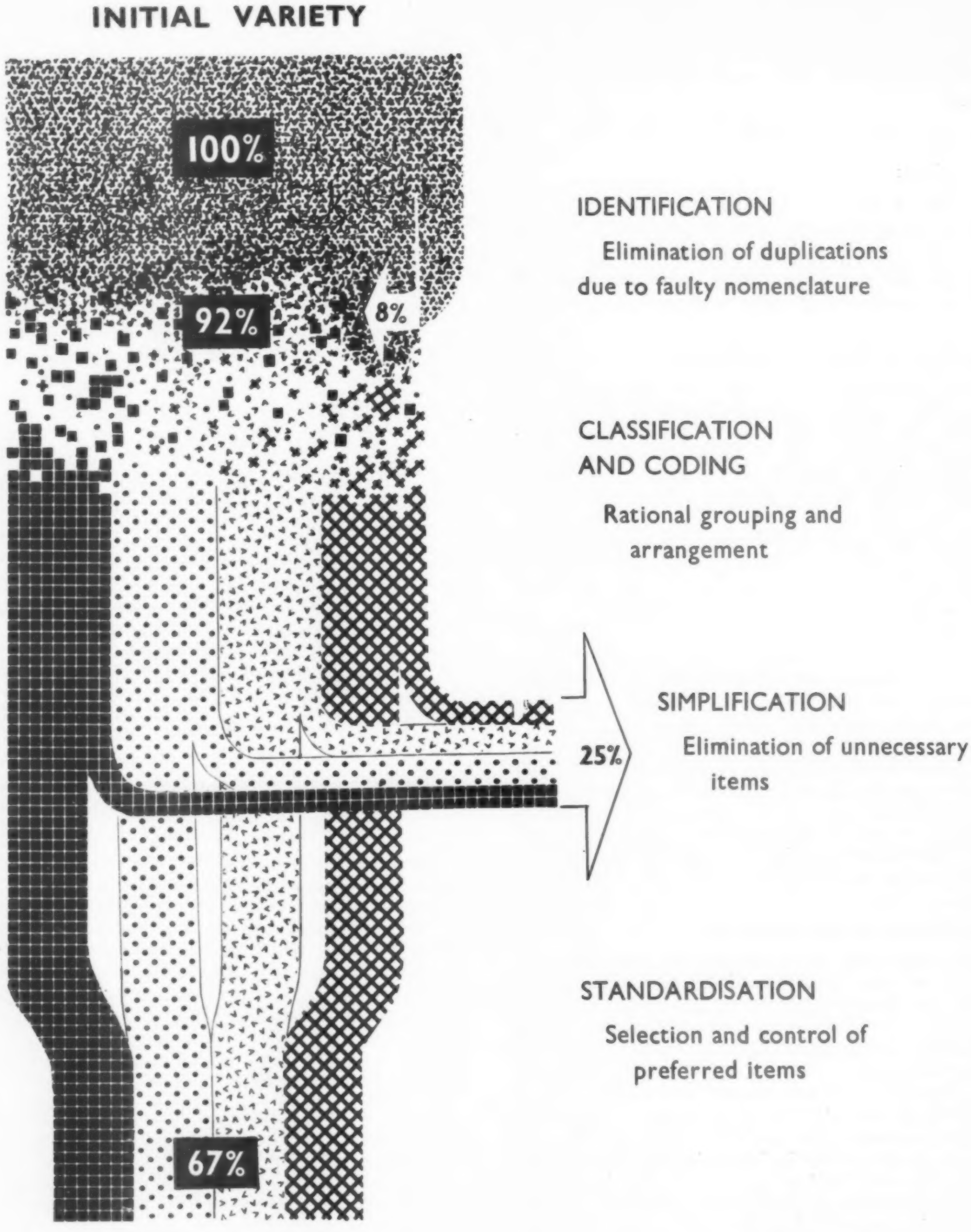
(i) *The inclusion of all the essential requirements of the user.* Every classified item has various characteristics and the selection of the characteristics which are essential *from the user's point of view* is of primary importance. The selection and the sequence in which the characteristics are then arranged, determine the design of the classification itself and of its numerical expression, i.e. the code. It is here that the specialist's skill and experience need to be applied. By ensuring that the characteristics conform to the essential needs of the user, two important principles are satisfied, namely:—

(1) a set of characteristics must denote one item and one item only;

(2) the characteristics must be arranged so that the classification proceeds systematically from the general to the particular.

These restrictions leave considerable freedom to choose the characteristics and an even greater latitude to determine the sequence in which to list them. On the other hand, this freedom is restricted by the stipulation that the characteristics must conform to the essential needs of a given user. Only by accepting this limitation is it possible to ensure that all the items capable of satisfying similar needs are brought together when classified. Since these needs vary from one firm to another, the characteristics and sequences selected will also be different in each case.

(ii) *The logical selection of the common denominator of characteristics.* In classifying, for instance, plants, Linnaeus regarded their morphological characteristics as the common denominator, because similar plants possess parts of similar type, shape and location. But in industry there are no general rules to serve as a common denominator and characteristics must be selected to suit the user's essential and specific needs. The problem is to select the most significant characteristics of every item of materials, components, tools, plant or product used or produced by the firm, and, at the same time, to cover all their possible appli-



cations. Thus, for primary materials, the characteristics selected should disclose their nature (composition, physical properties, finish) and dimensional features. In the case of bought-out commodities, it is their functional characteristics; while in the case of components, it is usually the shape, not only because this is how they are first conceived by the designer, but also because the shape strongly influences his choice of the material and of the manufacturing process. Components classified in this manner are easily located. All interchangeable

or similar items capable of serving the same purpose are brought together. The cost of designing anew an existing part can be saved.

The Technique of Classification

Firstly, all items under consideration must be precisely and unambiguously defined.

Secondly, each item must be classified according to its basic characteristics.

This necessitates :—

(a) recording those characteristics which correspond to the user's requirements, thus forming an inventory of his needs;

(b) assessing the relative value of each need so as to form the sequence of classification upon which the whole framework is based;

(c) examining each item and in effect evaluating it according to the various functions or requirements it is capable of satisfying.

All industrial data in an organisation may be classified under ten general headings or main classes, e.g. :

0000 Organisation and operations
1000 Primary materials
2000 Bought-out commodities (" shelf " items)
3000 Manufactured components (to users' own drawings)
4000 Sub-assemblies and assemblies (products)
5000 Tools and portable equipment
6000 Plant and machinery
7000 Real estate, services, utilities
8000 Scrap. Waste
9000 Reserved

Each class is further divided into sub-classes, groups and series and covered by a Code Number, each digit of which is descriptive and meaningful.

For example, bright mild steel tube, round, seamless, 0.750 in. O/D x 10 S.W.G. might be coded 1174–401, analysed as follows :—

CLASS	1 * * * – * * *	– Primary material
SUB-CLASS	* 1 * * – * * *	– Iron and carbon steel
GROUP	* * 7 * – * * *	– Tube
SERIES	* * * 4 – * * *	– Mild steel
	* * * * – 4 * *	– Round, seamless, specified lengths
	* * * * – * 0 1	– 0.750 in. O/D x 10 S.W.G.

The Code and the Catalogue

The final classification takes the form of a catalogue of code numbers and item descriptions. It becomes a " common language " throughout the organisation, enabling anyone to determine any item with complete certainty, and provides rational standardised definitions. I feel that it can be claimed that, as a result of the techniques evolved, the Code

is essentially simple;

is technologically correct;

is constructed so that each digit expresses a simple meaning by virtue of its value and position;

can be interpreted by unskilled personnel;

embraces all the users' present needs and allows for expansion to cover future needs, since it is designed to suit the specific requirements of each particular organisation concerned;

eliminates the need to memorise the code numbers, since, because of the descriptive nature of the code, they soon become associated with the items themselves, and errors due to the human element are greatly minimised.

How the Code is used

After the establishment of the catalogue has brought to light concealed duplications and has already eliminated part of the unnecessary variety, the Coding Officer, who has been trained in and is responsible for the operation and maintenance of the Code, has the following functions to perform :—

(i) preventing any unnecessary variety from being introduced by critically examining all proposals for the addition of new items in the catalogue with a view to finding out whether an existing item can be used, and, if not, whether one or more existing items can be discarded when a new one is introduced;

(ii) eliminating, by methods already mentioned, those items whose retention cannot be justified and preventing their being re-ordered.

So far as components are concerned, many new drawings are produced because it is either impossible, or it takes too long, to find the existing part drawings. The Code brings like items together and the numerical character of the Code allows for very quick comparison of all similar drawings. Consequently, before a new component is designed, all existing drawings of the same or similar shape can be quickly produced to see :—

(a) whether an existing part will serve the purpose, with slight modification if necessary, so as to avoid the cost of designing, tooling, purchasing, planning, progressing and storage associated with every new part, and the loss in production and pre-production time which inevitably results from the introduction of a new component;

or (b) whether, if no existing part will serve the new purpose, the new one can be so designed as to serve also the purpose of some of the old ones, thus enabling the latter to be eliminated with the result that the variety of holdings is not increased. In addition, old tools can often be modified to produce the new part, which is another potential source of appreciable savings.

After the elimination of items which fulfil identical needs and those for which no justification can be

IDENTITY CONCEALED—

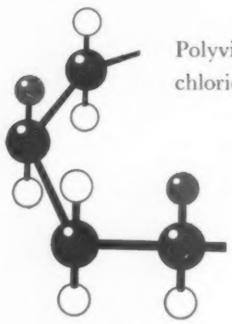
Under proprietary names

Under conventional designations referring to function or application

Under reference to location

IN THE SAME FIRM

The same material



has been found to be commercially available under the following proprietary names :

BX PVC	Li-Lolastic
Capovin	Lorival
Cap-Plastube	Marvinol
Chlorovene	Mipolam
Clorcom	Periflex
Corvic	Portex Vinyl
Craylene	Rilene
Duraplex	Tenaduct
Erinoid	Tygan
Everflex	Vinatex
Flexatex	Vinylite
Koroseal	Vynan
Kenutuf	Welvic

The same type of component

was separately designed, produced and stored as :

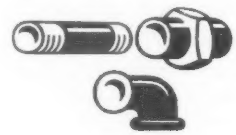
Arbor	Plug
Axle	Plunger
Bar	Post
Bolt	Rivet
Boss	Rod
Button	Roller
Column	Shaft
Cotter	Shank
Dowel	Spigot
Mandrel	Spindle
Peg	Stud
Pillar	Tappet
Pin	Trunnion
Piston	Valve
Pivot	

It was also found under composite names, such as :

Pin anchor	Pin link
Pin crank	Pin hinge

Pin push lever
Pin clamp plate
Clutch toggle pin
Governor drive coupling pin
Distributor drive plain pin

The same pipes and pipe fittings



were found in stores in three different locations according to their use :

1. FACTORY MAINTENANCE STOCK
   Piping for gas, water, compressed air.

2. PRODUCTION STOCK
   Parts used in construction of products.

3. PLANT SPARES
   Parts serving machine tools.

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found, all other items which are closely related and which the Code has brought together, are critically examined. Accumulation of numerous entries is often a pointer to needless variety. In the case of components, those having but one use should be considered as the first to be eliminated, while those having several functions are usually retained. This stage of the work requires a thoroughly analytical approach, because small quantities, having often a slow rate of stock turnover, are not *necessarily* those items which can be dispensed with, while on the other hand, those extensively used are not *always* the ones to retain.

Generally speaking, classification designed for the specific requirements of each particular organisation, as opposed to one of more universal application, quickly indicates the field of action and establishes priorities for an orderly programme of simplification and standardisation. The work is facilitated and quickened and nothing is left to chance or haphazard decisions.

The descriptive nature of each digit indicates, in many instances, common characteristics between classes. For example, if the figure 3, as the third digit in a Primary Material Code indicates " Round Bar ", the same figure, as the second digit in the component code, could indicate a straight centre line cylindrical component; if the first digits of a code number representing " Hand or Portable Hammers ", were 5210, and those representing " Machine Hammers "—6210, then the operation of hammering would be 0521 if manual or 0621 if by machine. There is, therefore, what may be described as a horizontal relationship between the various classes.

Results of Good Classification—Some Examples

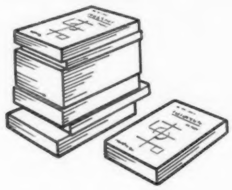
The first outcome of systematical classification is that all identical items are revealed, whose nature has hitherto been hidden by misleading and fortuitous nomenclature. For example, an identical item was found under tinned copper wire, copper flex and braid. Identification disclosed that eleven apparently

IDENTITY CONCEALED—

Under reference to customers

Each year a firm producing sheet metal components

prepared	received
40,000	4,000
estimates	orders



all classified under clients' names.

How could the D.O. possibly find out:
- — whether the same component was already designed for other clients?
- — whether existing tools, slightly modified if necessary, could be used to produce the required components?

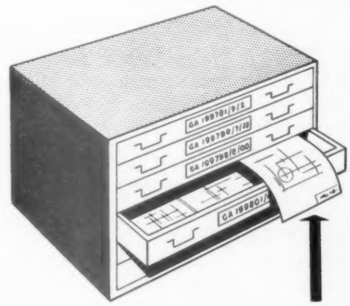
Result.
- — for each tender: a new design;
- — for each order: a new set of tools.

UNNECESSARY VARIETY

A designer in an engineering firm would rather draw a new component than undertake the formidable task of finding a similar and already existing one.

Thus he designed an " Operating Arm " unaware that there was in existence a very similar " Lever ", the blank of which could be directly used for the new component.

Furthermore—if the first drawing could have been found, in all probability the actual component itself and many others related to it, such as shaft, bearings and brackets, could be directly used.



Cause.

Different descriptions and different numbers for identical or similar components, relating them to their assemblies only.

Result.
- — new component manufactured;
- — new tooling designed and made for blanks which were actually in stock;
- — additional work imposed on the purchasing, costing, time study, production control and manufacturing departments.

---

different kinds of flat mild steel corresponded, in fact, to two specifications only. 2 B.A. Studding was found under eight different names. Such concealed duplication seldom amounts to less than 10 per cent. of the number of varieties held. Items almost identical, differing by an insignificant feature only, become a single item under the same code after classification. Redundancies are thus revealed and by the removal of unnecessary holdings the first savings are effected.

Next there are revealed those items, the need for which has been greatly reduced or has completely vanished, i.e. the slow moving or idle (dead) stocks. Classification enables them to be :—

(a) used as alternative material in their present state for current production;

(b) fully utilised after small modification, reprocessing or re-working (e.g. rod or wire redrawn to a size in greater demand);

or

(c) exchanged against more commonly used material.

Stock levels are therefore reduced, the rate of turnover increased, storage space used more economically and stores layout improved.

The following examples of the results of application of rational classification illustrate the contributions made by this method towards improving productivity and reducing costs.

(a) Reductions of up to 10 per cent. in the number of drawings produced have been achieved, resulting in savings up to £10,000 per annum.

(b) 10 per cent. of a firm's 15,000 tools were found to be no longer in use. With the help of the code they were brought back into operation to make new components at a modification cost of one-third cost of new tools.

(c) The delivery of twelve machines, at £10,000 each, was in danger of being held up due to

the faulty processing of one component. No spares or raw material were available but the code revealed that components belonging to an entirely different machine and of the right material existed, and these were easily substituted for the rejected parts. An otherwise inevitable and appreciable delay was avoided and delivery made on time.

(d) Many cases of up to 40 per cent. of materials eliminated and storage space reduced by as much as one-third are on record. 6,000 varieties of Primary Materials held by one firm were reduced to 3,500. As a result, purchases of certain materials were suspended while the factory lived on its stock of these materials for over three months.

(e) 129 varieties of oils, held by one firm of world-wide renown, were reduced to twenty-two.

(f) The time required to make the inventory at an electrical firm was three to four weeks. After classification and coding by the Brisch method, this was reduced to two to three days.

(g) 66 sizes in three grades of case hardening carbon steel rods were reduced to fourteen sizes in one grade.

(h) For a packaging carton, box-maker's linen was originally specified. Classification grouped all similar cartons and revealed that in this single instance an expensive material was being used. As a result, a cheaper material, which passed all the tests to which the linen had been subjected, was substituted. A saving in material cost of £8,000 per annum was obtained.

Direct Financial Benefits

In the main, the savings resulting from good classification and coding are two-fold.

(i) *Those arising from stock reduction and increased rate of stock turnover.*

The Mutual Supply Agency has established that the annual cost of stock holding should be assessed at 25 per cent. of the stock value, taking into account the cost of capital, accommodation, handling and maintenance, clerical procedures of purchasing and stock control, insurance and loss through deterioration, pilferage and obsolescence. This figure is based on American conditions and might be considered high for conditions in the United Kingdom. Investigations with a number of firms in this country have revealed that this annual cost of holding stock varies between 15 and 25 per cent. of the value of the stock held. Savings arising from, say, 10 per cent. stock reduction can therefore be quite appreciable.

A 50 per cent. increase in the rate of stock turnover can bring about an annual saving equivalent to 5 per cent. of the value of the stocks, if the lower figure of 15 per cent. is taken. For example, if the stocks held amount to £300,000 and the rate of turnover is increased from two to three times per year (50 per cent. increase) by the elimination of idle, slow moving and unnecessary items, then the annual saving amounts to 5 per cent. of the £300,000 or £15,000 per annum. (A 20 per cent. increase in turnover would yield 2½ per cent. or £7,500 per annum.) In addition, capital to the value of the stock reduction is released for more essential purposes.

(ii) *Those arising from the prevention of unnecessary new component manufacture and tooling and the elimination of duplicate and superfluous variety.*

The easy accessibility of old drawings for many years past enables the designer to use existing components, their blanks, castings or forgings as such, or slightly modified if necessary, instead of designing new ones.

It has been found that duplication of identical and fully or partly interchangeable items, due solely to misleading nomenclature and faulty coding, is seldom less than 10 per cent. and often as high as 15 per cent. of the total amount. Simplification, correctly applied, results in a corresponding saving not only on materials and labour, but also on all corollaries such as designing, tooling, production planning, stock control, handling and clerical work.

Usually such subsidiary costs amount to not less than £15 and, in some cases, as much as £50, for each variety held.

If, therefore, the output of a Drawing Office amounted to, say, 1,000 drawings per year, the savings secured by an elimination of 10 per cent. of duplicate component drawings would, at a conservative estimated cost of £20 per item, amount to £2,000 per annum in these costs alone.

In addition to the savings arising from the *prevention* of the preparation of duplicate or similar drawings in the future, action can be taken to apply simplification by *eliminating* the unnecessary components and tools already in existence which have been brought to light by the code book. While the time and money already spent on the designing, drawing, tooling, ordering, planning, programming, handling, stocking and clerical costs cannot be recovered, the cost of retaining and replacing superfluous components and their tools is saved for each variety dispensed with.

Furthermore, the Production Controller is aided in his programming and planning. The Time Study Engineer can more easily synthetise time standards. Work routing becomes automatic, and the foreman can plan his machine loading to reduce setting up time to a minimum. By following the sequence of code numbers the storekeeper obtains a better utilisation of the storage space available because items of related size and type are kept together. The code numbers are at the same time location numbers (for example, bin or file numbers) and allow for instantaneous finding of a drawing in the Drawing Office, a record in the Purchasing or Stock Departments or an item in the Stores.

Where mechanised accounting is in operation considerable saving in punch card space is achieved where descriptive code numbers are used. Not only do these codes identify and describe each item but they can be used directly for mechanical sorting.

As only numbers and no letters are used the sorting time is reduced.

The material benefits which the Code provides are by no means the only ones. The Code also gives its users new *habits of thought*. It stimulates their determination to simplify and to obtain the maximum usage from all available resources, to reject every new addition which is not manifestly an improvement or a necessity, and to strive continually for both technical and economic progress—in other words, for the means to achieve higher productivity in the widest sense.

PRACTICAL INTERPRETATION OF DRAWING LIMITS

The Engineering Metrology Association has been asked by the British Standards Institution to collect data which will assist in the compilation of British Standard Specifications and in the preparation of a handbook on gauging practice to be published by the Institution. A sub-committee of the Association has been formed for the purpose of co-operating with the B.S.I. in the collection of information. Several members of the Association sit on the B.S.I. technical committee concerned with gauging principles and practice.

Members and others are asked to offer any information within their experience on the matters detailed below. In any publication arising from such information, due credit will be given to the Association but names of firms or individuals will not be revealed.

Experience of the gauging of female threads with long-flank "Not Go" gauges: comparison of results obtained from long-flank gauges with those obtained from short-flank gauges, particularly on threads with bad thread form.

(*Note*: This information is urgently required by the B.S.I.)

Suitability of standard-type gauges for their intended purposes; cylindrical plug gauge, cylindrical-ended bar or plate gauge, spherical or spherical-edged disc gauge, etc.

Comparison between the use of fixed gauges and direct measurement in production inspection by mechanical, pneumatic, electrical or other methods.

Details of systems where measurement is used at the machine, but fixed gauges are used for inspection; other systems where shop and inspection methods differ.

Preference or otherwise for dimensional comparison by indicating gauges.

Gauging methods for errors of form.

Gauging of non-rigid components (i.e. those having slender sections which may deflect under normal measuring pressure).

Any methods of measurement or gauging which have been used in the settlement of disputes, e.g. between supplier and customer.

Any further comments on gauging methods in general.

Replies dealing with any or all of the above items should be addressed to:

The Technical Secretary,
Engineering Metrology Association,
Northampton Polytechnic,
St. John Street,
London, E.C.1

as early as possible.

DIPLOMA IN PERSONNEL MANAGEMENT

The Department of Economics and Social Science in co-operation with the Department of Industrial Relations offers a sessional course in Personnel Management for students who intend to specialise in problems of human relationships in industry or closely related fields.

The course is designed for a small group of 8—10 students who will be carefully selected and given considerable individual attention during their year in Cardiff. Thanks to the readiness of local business firms to offer facilities for visits of observation and periods of practical work in personnel departments, students are given regular opportunities of testing academic principles in practical situations.

Applications will be considered from candidates who are

(a) graduates of British Universities, or

(b) holders of Social Science Diplomas, or

(c) older men and women (24 years and over) with a satisfactory academic background, who are nominated by their company to take the course, or who may wish to enrol on their own initiative.

Candidates will be expected to have gained some industrial or commercial experience before beginning the course.

Students are selected by interview and record. Senior Personnel Managers have promised to help in this selection, which will incidentally admit the student to membership of the Institute of Personnel Management. The closing date for applications is June 15th, 1954, and full particulars may be obtained from the Department of Economics and Social Science, University College, Cathays Park, Cardiff.

CORRESPONDENCE

Correspondence is invited on papers and articles appearing in the Journal, or on any matters of interest to production engineers. Letters should be addressed to the Editor, 10, Chesterfield Street, London, W.1.

REPORT OF THE MEETING OF COUNCIL

Thursday, 29th April, 1954

THE last Council Meeting of the present Session was held at 36, Portman Square, London, W.1, on 29th April, 1954. The Chairman of Council presided over the meeting, at which thirty-two members were present.

Before proceeding with the business of the meeting, the Chairman welcomed Mr. M. J. Hemmett, Chairman of the Luton Graduate Section, and Mr. H. W. Badger, M.A., the Institution's Education Officer, who were attending Council for the first time.

Ad Hoc Committee on Finance

A motion put by Mr. R. E. Leakey, London Section President, on behalf of the London Section Committee, that an Ad Hoc Committee be appointed to examine the financial position of the Institution, was negatived by 23 votes to 7 votes.

The general feeling of Council, as expressed by several members, was that the financial position of the Institution, as set out in the published accounts and in the detailed statement which had been issued as an Appendix to the Council Papers, was satisfactory and reflected credit on the good management, through some difficult times, of the Finance and General Purposes Committee. Those responsible had concentrated not on the mere saving of money, but on employing the funds so that the Institution's future development would be safeguarded.

The New Headquarters

The Secretary reported that the new headquarters would be occupied early in May. The total capital cost of acquiring and adapting the premises for use as a headquarters would be in the region of £50,000. The sum of £10,000 had been received in the form of donations to the Building Fund. If no further donations were received, the Institution's overdraft at the end of the financial year would be of the order of £9,000 or £10,000.

Council Election, 1954/55

It was agreed that the twelve members elected to Council under the old Constitution should all retire this year, instead of only six members retiring as was customary, so that the new Council could be set up strictly in accordance with the revised Articles of Association.

Election of Principal Officers, 1954/55

The Council approved the Finance and General Purposes Committee's recommendation that the following be elected:

President	Sir Walter Puckey.
Chairman of Council ...	Mr. G. R. Pryor.
Vice-Chairman of Council	Mr. H. G. Gregory.

Regional Organisation

The Chairman reported that since the last Council Meeting the Ad Hoc Committee on Regional Organisation had held one meeting, when problems of Regional organisation had been discussed. Some time had been spent on the question of election of officers, and he had been informed that six Regions out of the twelve had completed their arrangements, and that the remaining six were in the process of doing so.

The question of regional finance was still being discussed at Regional and Section level, but generally speaking it seemed as though the proposed scheme would be adopted.

American Society of Tool Engineers

It was unanimously agreed that a telegram of congratulation be sent to Mr. J. P. Crosby, the incoming President of the American Society of Tool Engineers. Mr. Crosby becomes an honorary member of the Institution on his election as President of the American Society of Tool Engineers.

Education Policy

The Education Committee reported that they had had considerable discussion on the possibility of adjusting the Institution's examination syllabus to make it possible for students whose basic technology was not Mechanical Engineering to enter the Institution.

The discussion had been suspended temporarily whilst the views of Sections were obtained on the recently circulated Report on "Broadening the Base".

Examination Fees

On the motion of Mr. S. A. J. Parsons, Chairman of the Membership Committee, seconded by Mr. E. P. Edwards, the Council adopted a recommendation by the Membership Committee that a revised

schedule of fees should be introduced. The revised schedule includes the introduction of an initial Registration Fee, which will be credited to an applicant as part of his first year's subscription, and also amends the Examination Fees so as to make the fee paid conform more closely to the actual cost incurred for each part. Exemption fees will also be introduced.

It was agreed that the revised schedule would take effect from 1st July, 1954. Full details will be available to members as soon as a revised " Membership and Examination Regulations " booklet can be printed.

Production Exhibition and Conference

It was reported that virtually all the Exhibition space had been taken up. Arrangements for the Conference programme were complete, and details would be circulated to members with the May Journal.

Annual Dinner

It was reported by the Finance and General Purposes Committee that the Institution's Annual Dinner would be held on Friday, 8th October, 1954, at the Dorchester Hotel, London.

The Journal

Under the guidance of the Editorial and Papers Committee, the standard of material appearing in the Journal had been maintained, and a wide range of subjects of interest to production engineers had been covered.

The Editorial Committee had been fortunate in obtaining authoritative contributions to the present series of leading articles, " Universals of Production ", some of which had attracted considerable notice in the national press.

Institution Awards

Two Sub-Committees had been appointed by the Papers Committee to assess Papers for the 1952/53 Awards, and were proceeding with this work.

Summer School

It was reported by the Education Committee that the finally-selected theme for the 1954 Summer School would be " Practical Training for Production Engineering ", and would not be restricted to apprentice training as previously announced.

Liaison with Sections outside U.K.

On the suggestion of the Vice-Chairman of Council (Mr. G. R. Pryor), Council expressed their sincere thanks to Mr. J. E. Hill for his generous offer to take into his works for training one student, each year, from Australia.

The Vice-Chairman also referred to the Chairman's recent visit to the Canadian Section, and read to Council a letter subsequently received from the Section, in which they expressed their great appreciation of Mr. Burke's visit, and their continued enthusiasm for and interest in the Institution.

The Chairman emphasised the valuable potentialities of the Canadian Section, and stressed the fact that in view of its remoteness from the U.K. the greatest help and co-operation in its development must be forthcoming from the Institution in London.

Materials Handling

The newly-constituted Sub-Committee on Materials Handling reported that they had met twice since the last report, and had drawn up new terms of reference which had been approved by the Research Committee.

It was proposed to hold a one-day Exhibition and Conference in the autumn.

The Sub-Committee had suggested that a Report be produced on " The Cost of Handling ", in collaboration with the Institute of Cost and Works Accountants and the Institute of Materials Handling, and a joint meeting had been held to discuss this proposal.

Production Control

The Sub-Committee on Production Control reported that in collaboration with the Works Statistics Sub-Committee of the I.C.W.A., they had drafted a Report which it was hoped would be published towards the end of the year.

Materials Utilisation

The Sub-Committee conducting this investigation reported that material was now being collated for the publication of their Report.

Research

The Research Committee were pleased to report that the Institution's co-operation and support had been requested by the University of Southampton, in connection with a survey into " The Impact on British Economy of American-originated Companies Operating in the United Kingdom ".

Standards

An article by the Chairman of the Standards Committee, Mr. C. M. Holloway, reminding members of the importance of standardisation, had been published in the April issue of the Journal.

Library

It was reported by the Library Committee that work was proceeding steadily on the Catalogue, which should be in the hands of the printers by June.

A number of members had recently offered to assist in the work of abstracting and reviewing books, and the Committee accepted these offers with gratitude and pleasure, and thanked other members for their continued support in this matter.

Conference on Production Information

It was reported that approximately twenty members of the Institution attended the successful Conference on Production Information held at the

College of Aeronautics, Cranfield in April. The speakers included four members of the Institution—Mr. M. Seaman, Chairman of the Editorial Committee; Mr. L. J. Saunders and Mr. G. Cubitt-Smith, members of the Library Committee; and Mr. Peter Spear.

Formation of Tees-side Section

The Council approved the Finance and General Purposes Committee's recommendation that a new Section of the Institution be established on Tees-side.

Local Section Reports

Council received the Local Section Quarterly Reports, extracts from which appear on pages 356–359 of this Journal.

Elections and Transfers

The Council approved a number of recommendations for election to membership, and transfers, particulars of which appear on pages 354 and 355 of this Journal.

Honours

The Council noted with pleasure that Her Majesty had conferred the award of M.B.E. on the following members of the Institution:

Mr. F. R. Charlton, Associate Member.

Mr. J. Hastings, Associate Member.

Obituary

The Council recorded with regret the deaths of the following members:

Mr. J. A. Hannay, Hon.M.I.Prod.E.
Mr. G. I. Horton, A.M.I.Prod.E.
Mr. A. W. B. MacGregor, A.M.I.Prod.E.

In paying tribute to Mr. Hannay, the Chairman referred to his invaluable and enthusiastic service, as one of the first 500 members of the Institution.

Tribute to Chairman

Mr. J. E. Hill said that as this was the last occasion on which Council would be composed of the present members, he thought it fitting to thank the Chairman for the very able manner in which he had conducted the meetings. He was sure he spoke for all members of Council when he said they had been pleased to sit under Mr. Burke's guidance.

Mr. A. L. Stuchbery said he would like to associate himself with Mr. Hill's remarks, and hoped that Mr. Burke would feel a great deal of satisfaction in the progress that had been made under his Chairmanship.

In a brief reply, Mr. Burke expressed his sincere thanks for the Council's appreciation of his efforts and for their constant support during his period of office.

Date and Place of Next Meeting

The next meeting of Council was arranged to take place at 11.0 a.m. on 22nd July, 1954, at 10, Chesterfield Street, London, W.1.

ELECTION OF MEMBERS

29th April, 1954

ADELAIDE SECTION

AS ASSOCIATE MEMBERS
J. L. Naylor, J. L. Nunns.
NEW AFFILIATED FIRM
Horwood Bagshaw Ltd.
NEW AFFILIATED REPRESENTATIVES
M. J. Sykes, A. R. Middlebrook.

BIRMINGHAM SECTION

AS ASSOCIATE MEMBER
C. C. Jordan.
AS GRADUATES
R. Collett, E. P. Harris, J. E. Karle, D. M. Lovett H. Scholes, J. B. Tompkin.
AS STUDENTS
K. A. Brookes, B. H. Dewick, J. A. Durrant, M. G. Everiss, C. M. Johnson, D. Keeling, K. Maddison, J. H. Washbrook.
TRANSFERS
FROM ASSOCIATE MEMBER TO MEMBER
A. Y. Stirrat.
FROM GRADUATE TO ASSOCIATE MEMBERS
C. E. Cox, A. P. Morris, J. P. Robinson, G. C Walford.
FROM STUDENT TO GRADUATE
P. Hayward.

BOMBAY SECTION

AS ASSOCIATE MEMBERS
M. N. Appoo, Capt. S. Balasubramaniam.
AS GRADUATE
S. Krishnamurty.
AS STUDENT
V. K. Vij.
TRANSFERS
FROM ASSOCIATE MEMBER TO MEMBERS
L. L. Gonda, G. E. Townsend.

CALCUTTA SECTION

AS ASSOCIATE MEMBER
Lt.-Col. G. S. Bedi
AS STUDENTS
A. Haleem, N. K. Mathur, S. Hussain.
TRANSFER
FROM GRADUATE TO ASSOCIATE MEMBER
A. Akhikari.

CANADA SECTION

AS STUDENT
H. Akhtar.
TRANSFER
FROM GRADUATE TO ASSOCIATE MEMBER
D. L. McNamara.

CORNWALL SECTION

AS STUDENT
A. R. J. Simon.
TRANSFER FROM
FROM GRADUATE TO ASSOCIATE MEMBER
J. F. Horler.

COVENTRY SECTION

AS ASSOCIATE MEMBER
A. E. Washbourne.
AS GRADUATES
H. E. Coelho, P. J. Wright.
AS STUDENT
H. J. Radford.

DERBY SECTION

AS GRADUATES
S. Groves, W. J. Lambert, G. Sparham.
AS STUDENTS
N. Henshaw, K. B. Hulley.
TRANSFER
FROM GRADUATE TO ASSOCIATE MEMBER
G. Fox.

EASTERN COUNTIES SECTION

AS MEMBER
J. A. Danielli
TRANSFERS
FROM ASSOCIATE MEMBER TO MEMBER
L. L. Bott.
FROM GRADUATE TO ASSOCIATE MEMBERS
B. R. Bensly, N. Holmes, H. R. Stansfield.

EDINBURGH SECTION

AS STUDENT
I. C. Noble.

GLASGOW SECTION

AS ASSOCIATE MEMBER
E. W. Tough.
AS GRADUATE
W. R. Smith.
AS STUDENTS
A. C. Bell, J. Walker.

GLOUCESTER SUB-SECTION
AS GRADUATE
P. F. Jowitt.

LEICESTER SECTION
AS ASSOCIATE MEMBER
T. Humble.
AS GRADUATES
R. J. Edwards, T. W. Green, P. C. Hawkes.
AS STUDENTS
M. J. Brown, J. K. C. Pegg, T. H. Preston, W. G. Whiteley.
TRANSFER
FROM STUDENT TO GRADUATE
E. Newman.

LINCOLN SECTION
AS STUDENT
D. G. Waddingham.

LIVERPOOL SECTION
AS ASSOCIATE MEMBER
H. C. Swain.
AS GRADUATE
A. Ellison.
AS STUDENTS
E. J. Crompton, J. Grimshaw.
TRANSFERS
FROM STUDENT TO GRADUATES
D. G. Davies, F. Tilston.

LONDON SECTION
AS MEMBERS
C. F. Collins, A. J. B. Combs, F. C. Garner, F. H. B. Kelson, F. C. Lock.
AS ASSOCIATE MEMBERS
G. A. Black, F. A. Clarke, H. Cousins, P. Davie, H. J. Elton, Maj. E. G. Hughes-Jones, C. Matthews, H. B. Merriman, M. L. Puri, A. C. Rayment, A. Robb, D. C. Robinson, S. C. Rouse, J. C. Thompson.
AS ASSOCIATES
F. Corry, T. C. Payne, O. Walker.
RE-INSTATEMENT AS ASSOCIATE
F. G. E. Gardiner.
GRADUATES
J. M. Ackland, P. Spence-Brown, J. G. Hancock, I. A. Khan, J. C. R. Nicholson, K. A. Rutter, D. G. J. Sellwood, G. P. Stopford, D. V. Watson, C. F. G. Williams.
AS STUDENTS
A. Ambrose, R. J. Biggs, R. F. Carroll, G. S. Cheeswright, B. P. Collins, P. L. Davey, J. A. Gow, P. J. Hobson, D. R. Lawson, K. Matta, K. E. Reader, R. M. Turk, J. F. W. Walker, J. B. Watson, K. J. Webber, A. J. Woodhead.
NEW AFFILIATED FIRM
C. C. Wakefield & Co., Ltd.
NEW AFFILIATED REPRESENTATIVES
C. F. Dennis, R. J. Turner.
ADDITIONAL AFFILIATED REPRESENTATIVE
Affiliated Firm
The LaPointe Machine Tool Co., Ltd.
ADDITIONAL AFFILIATED REPRESENTATIVE
J. P. Crosby.
TRANSFERS
FROM ASSOCIATE TO ASSOCIATE MEMBER:
A. F. Abdo.
FROM GRADUATE TO ASSOCIATE MEMBERS
R. W. Atkinson, S. Eilon, F. R. Simmons, L. G. Smith, R. L. Webb.
FROM STUDENT TO GRADUATES
R. A. Ahern, J. A. Churchill, N. Crawford, W. E. G. Speakman, C. E. Taylor, J. R. Waters.

LUTON SECTION
AS MEMBER
G. I. A. Spittle.
AS GRADUATES
P. Gripton, H. A. van Raalte, A. N. Young.
AS STUDENTS
J. A. Laurie, P. Shackleton, D. A. Slough.
TRANSFERS
FROM ASSOCIATE MEMBER TO MEMBER
J. Wilson.

FROM GRADUATE TO ASSOCIATE MEMBER
R. St. John Aylieff.
FROM STUDENT TO GRADUATE
A. D. P. Wright.

MANCHESTER SECTION
AS GRADUATES
A. R. Sen, H. B. Sharman, L. V. Smith.
TRANSFERS
FROM GRADUATE TO ASSOCIATE MEMBER
H. Moore.
FROM STUDENT TO GRADUATES
G. R. Connor, G. A. Redston.

MELBOURNE SECTION
AS ASSOCIATE MEMBER
N. G. Daws.
AS GRADUATES
R. E. Hind, E. Lemberg.
TRANSFER
FROM GRADUATE TO ASSOCIATE MEMBER
R. W. Page.

NORTH EASTERN SECTION
AS STUDENTS
C. T. Dowson, T. R. Yates.
TRANSFERS
FROM ASSOCIATE MEMBER TO MEMBER
A. Cameron, J. Farmery.
FROM GRADUATE TO ASSOCIATE MEMBERS
G. Pool, W. T. Ramsden.
FROM STUDENT TO GRADUATE
W. D. Beadle.

NORTHERN IRELAND SECTION
AS ASSOCIATE MEMBER
Major P. G. Nicholson.
TRANSFER
FROM GRADUATE TO ASSOCIATE MEMBER
P. A. McElwee.

NORWICH SUB-SECTION
AS MEMBER
C. W. Maddison.
TRANSFER
FROM ASSOCIATE MEMBER TO MEMBER
W. J. Ford.

OXFORD SECTION
AS STUDENT
D. J. Smith
TRANSFERS
FROM ASSOCIATE MEMBER TO MEMBER
H. Ashford.
FROM STUDENT TO GRADUATE
K. A. Perkins.

PRESTON SECTION
AS ASSOCIATE MEMBER
W. H. Preston.
AS GRADUATE
F. S. Caldwell.
AS STUDENTS
J. H. Brennand, W. Dearnley, F. Fort.
TRANSFERS
FROM GRADUATE TO ASSOCIATE MEMBERS
F. R. Clare, F. Partington.
FROM STUDENT TO GRADUATES
E. K. Langham, I. M. Woods.

READING SECTION
RE-INSTATEMENT AS ASSOCIATE MEMBER
H. W. Cullis.
AS STUDENT
W. A. Matthews.
TRANSFER
FROM ASSOCIATE MEMBER TO MEMBER
A. J. H. Stevens.

ROCHESTER SECTION
AS STUDENT
R. Caufield.

SHEFFIELD SECTION
AS MEMBER
C. F. Hurst.
AS ASSOCIATE MEMBER
J. Elvin.
AS GRADUATE
D. R. Wilson.
AS STUDENT
D. Strawbridge.

SOUTHERN SECTION
AS ASSOCIATE MEMBER
W. E. J. Scudamore.
AS GRADUATE
A. MacGregor Stewart.
AS STUDENTS
J. Craig, R. J. Culverhouse, D. R. Fendley, M. D. T. Kelly, A. Penny, K. E. Phillips, G. E. Worsfold.

SOUTH WALES SECTION
AS ASSOCIATE MEMBERS
T. N. Halliday, W. McLenaghan, J. C. Winter.
AS STUDENTS
L. D. Evans, T. J. Northall.

SOUTH AFRICA SECTION
AS ASSOCIATE MEMBER
S. Franklin.
NEW AFFILIATED FIRM
Thermal Welding Products Ltd.
NEW AFFILIATED REPRESENTATIVES
N. N. Webster, L. J. Lalor.

SOUTH ESSEX SECTION
AS ASSOCIATE MEMBER
T. H. Ward.
AS GRADUATE
R. N. Tandon.
AS STUDENTS
G. J. Richards, L. Strauss.
TRANSFERS
FROM ASSOCIATE TO MEMBER
R. H. Mead.
FROM GRADUATE TO ASSOCIATE MEMBER
J. B. Gower.

STOKE-ON-TRENT SUB-SECTION
AS ASSOCIATE MEMBER
G. Parry-Windsor.
AS GRADUATE
C. Eardley.
AS STUDENT
D. Wood.

SYDNEYS ECTION
AS MEMBER
G. B. Foote.
AS ASSOCIATE MEMBER
R. McKenzie Howells.
AS GRADUATES
E. R. Costa, D. C. Enderby.

WESTERN SECTION
AS ASSOCIATE MEMBERS
N. Curnock, H. J. Lock.
AS GRADUATES
R. J. Aldridge, C. N. Lister.
AS STUDENT
D. A. Provis.
TRANSFERS
FROM ASSOCIATE MEMBER TO MEMBER
L. E. Broome.
FROM ASSOCIATE TO ASSOCIATE MEMBER
H. A. Gordon.
FROM GRADUATE TO ASSOCIATE MEMBERS
P. K. Digby, J. Rogers.

WEST WALES SECTION
AS STUDENT
D. W. Owen.

WOLVERHAMPTON SECTION
AS ASSOCIATE MEMBER
R. C. Evans.
AS GRADUATES
A. M. Cooper, P. J. Maltby, A. K. Sinha.
AS STUDENTS
A. Alroy, A. B. Jones.

YORKSHIRE SECTION
AS MEMBERS
F. W. Armytage, G. Mortimer.
AS ASSOCIATE MEMBERS
W. Sanderson, J. A. Spence.
AS GRADUATE
S. K. Basu.
TRANSFER
FROM GRADUATE TO ASSOCIATE MEMBER
E. G. Routledge.

NO SECTION
AS ASSOCIATE MEMBER
E. W. Jupp.
TRANSFERS
FROM GRADUATE TO ASSOCIATE MEMBERS
A. A. Ryall, E. E. Harris, R. W. P. Johnson.

DIRECT READING HARDNESS TESTING

A Committee of the British Standards Institution is at present engaged in the revision of B.S.891 : 1940, and would be grateful for any information which could be supplied by members of the Institution of Production Engineers regarding the extent to which the many Rockwell scales now current, other than A. B. or C., are in use.

Any members who are able to help in this matter should write direct to the B.S.I., at 2, Park Street, London, W.1, quoting the reference MEE/37/9/1.

RESEARCH PUBLICATIONS

A number of copies of the following Research publications are still available to members, at the prices stated :

Report on Surface Finish, by Dr. G. Schlesinger	15/6
Machine Tool Research and Management	10/6
Practical Drilling Tests	21/–

These publications may be obtained from the Production Engineering Research Association, "Staveley Lodge," Melton Mowbray, Leics.

EXTRACTS FROM LOCAL SECTION REPORTS

Presented to Council, 29th April, 1954

Adelaide

At the first Committee meeting for 1954, the programme for the year was decided. The first general meeting was held in February, when Mr. W. H. Schneider, M.E., gave a lecture on "Fatigue in Industry". During the session a local member, Mr. J. Messenger, A.M.I.Prod.E., will present a Paper on "Stretch Wrap Forming".

Birmingham

The second half of the session's activities opened in January when Mr. Tom Wylie, Dip.Pol.Econ.Sc.(Oxon.), presented an interesting lecture on "The Trade Union in Engineering Production". A very lively discussion followed.

In February, Mr. J. B. Mitford explained, with the aid of many slides and samples, some of the manufacturing techniques and uses of glass fibres.

The Annual Dinner Dance took place in February and was a most successful function. The Section were honoured by the attendance of the Institution President, the Lord Mayor and Lady Mayoress, the Vice-Chancellor of the University, and the Principal of the College of Technology.

The joint meeting with the Birmingham Productivity Association in March was addressed by Mr. N. I. Bond-Williams and Mr. Bernard Stokes, A.M.I.Prod.E. This led to a lively discussion on the impact of the B.P.A. on the industrial executive.

Birmingham Graduate

Early this year the Committee distributed a number of questionnaire forms for the purpose of furthering Institution activities among the Birmingham Section. The response was very good and of great value to the Section Committee. It showed that Graduates and Students are kept very busy generally and that nearly 20 per cent. of them are attending technical colleges either for the purpose of teaching or being taught. Several are members of H.M. Forces, and a number often work away from home but still remain attached to the Section near their home address.

It would seem from the replies received that Graduates and Students would prefer to hear lectures on a wide range of subjects, including some of the trades allied to engineering such as textiles, watchmaking, food and paper industries. Some requests were made for lectures on administrative subjects, and suggestions were made for subjects in the practical vein such as foundry safety precautions, reduction of costs in a small firm, and labour problems.

A disturbing feature is the fact that very few Graduates are allowed time off to attend works visits. A good works visit can provide a wealth of experience if well organised, but the value of the visit drops considerably if it is made during hours when factories are idle.

With regard to social activities, it was found that as a rule Graduates and Students are prepared to give support, but functions should not be too numerous as many members put much effort into their jobs and their studies. Outings of a semi-local nature such as the Farnborough Air Display are to be preferred, but functions designed primarily to introduce members to one another are appreciated.

Calcutta

Three Committee meetings were held during the quarter under review, to deal with the applications and other business.

In January, Mr. J. Blakiston, Chairman of the Halifax Section, gave a lecture on "The Production Engineer and India's Industrial Development". Also in January, Mr. B. A. Yashanoff, A.I.Prod.E., gave a lecture entitled "Productivity in Tea Gardens in North East India". A Film Show was held in March, by courtesy of the British Information Services, on "Furnace Practice and Boiler House Practice". Also in March, Mr. Shanti Sarup Jagota, D.M.E.C.(Hon.) Punjab, A.M.I.Mech.E., gave a lecture on "Chittaranjan".

Mr. N. N. Sen Gupta, M.I.Prod.E., Secretary, has assumed the duties of Treasurer.

Canada

The 1954 programme started with a visit to the Ford Motor Company's new factory at Oakville, near Toronto. This factory assembles Ford cars and trucks, which are made elsewhere, and it is the most modern plant of its kind in Canada. This visit was restricted to members and the total attendance was thirty.

The Annual General Meeting was held in March, when Mr. H. Burke, Chairman of Council, was the Guest Speaker.

Cornwall

In December, Mr. M. P. H. Le Vie, B.Sc., A.M.I.Mech.E., A.M.I.Loco.E., of the Aluminium Development Association, presented his Paper on "Recent Developments on the Economic Use of Materials", together with a film on Argon Arc Welding. The January meeting had to be postponed due to bad weather. The film evening in February was a great success. Nearly 300 members and visitors enjoyed the programme selected and presented by members of the Section Committee, which included films on Craftsmanship, Cutting Oils, Administration, and "Job 99—Pluto".

Mr. G. W. Trobridge, B.Sc., of The Dunlop Rubber Co., had an appreciative audience when he presented his Paper on "Some Applications of Rubber in Engineering" in March, and a long discussion followed.

Coventry

The lecture meetings continue to attract satisfactory attendances and there have been lively discussions. At the Annual General Meeting held in March, Mr. S. J. Harley, B.Sc., was elected Section President for a second year. Mr. R. F. Eaton, A.M.I.Prod.E., has retired from the position of Section Hon. Secretary, having taken up an appointment in Shrewsbury. The Committee wished him success in his new venture.

Three Papers presented by the Graduate Section in connection with the local Douglas D. Davis award were adjudicated by members of the Senior Section. All three Graduates were deservedly complimented on their efforts, but the unanimous decision awarded the first prize to Mr. L. K. Lord, Grad.I.Prod.E., for his Paper on "The Case for the Multi Spindle Automatic".

Arrangements for the Annual Dinner and Dance in October are well in hand.

Coventry Graduate

A film evening in January was followed in February by a joint meeting with the Technical Administration Group of the Coventry Technical College. This took the form of a Management Forum, and it appears that this type of meeting has more appeal to members in this area.

After the Annual General Meeting in April, the Committee will be finalising plans for next year's lecture programme and suggestions from members will be most welcome. It is also hoped to hold one or two social functions during the summer months, including a Treasure Hunt of the type that proved so popular last year.

Doncaster Sub-Section

The year commenced with a very interesting lecture and film evening on "Mechanical Handling". The lecturer.

Mr. W. Oldfield, represented the Mechanical Handling Association, who provided the films. In February, the Section was officially inaugurated, and a Presidential address was given by Sir Walter Puckey, to a large and appreciative audience of Doncaster business executives, members and visitors.

In March the Annual General Meeting was held prior to a lecture by Dr. D. F. Galloway, of P.E.R.A. At this meeting, Mr. G. R. Whitehead was elected as Section Chairman for the year 1954/55, and Mr. W. H. Edwards-Smith, was re-elected as Section Hon. Secretary.

In this quarter a number of new members has been proposed. Considerable interest appears to have been created, more so since the visit of the President. A very enthusiastic Committee have done a great deal to ensure the success of the lecture meetings.

Eastern Counties

During the period under review lecture meetings have been well attended by members and visitors. The January lecture was given by Mr. E. H. Boas on "The Planned Production of Rayon Fabric". His talk was illustrated by a film, and samples of various types of rayon were shown. At the February meeting nearly sixty members and visitors were present to hear Mr. M. Seaman, M.Sc., M.I.Mech.E., A.M.I.E.E., M.I.Prod.E., talk on "The Structure of Production Management". His Paper was well received and was followed by a lively discussion.

In March, the Annual General Meeting preceded a Symposium on "Recent Developments in Machines and Tools". Four Papers were given at this meeting describing some machines, tools and machining methods used in engineering firms in the district.

Glasgow

The 1953/54 lecture programme has now been completed. During the last quarter Papers on the following subjects were presented in Glasgow: "A Comparison of Productivity in the United States and Britain"; "Spheroidal Graphite Cast Iron"; "Noise and Vibration in Machinery".

Open Discussion Nights still prove to be very popular and in March two local members led a discussion on "The Economic Use of Material".

At the Annual General Meeting of the Section Mr. M. C. Timbury was elected Section Chairman for 1954/55 and Mr. J. Menzies was elected Vice-Chairman.

Halifax

After many years' valuable service to the Institution, Mr. Arthur Sykes has resigned from local Committee work, and the vacancy created by his resignation was filled by the election of Mr. A. E. Clifford, who has recently been transferred from the Northern Ireland Section. Mr. F. J. Everest was elected President, Mr. W. A. Hannaby, Vice-President, and Miss N. E. Bottom, Hon. Section Secretary.

Following this meeting, the Chairman introduced Mr. K. K. Collinson and Mr. T. P. N. Burness, both members of the Section, to present Papers.

Lincoln

During the period under review members have visited the gas turbine section of Ruston and Hornsby Limited. This was a very interesting and enjoyable evening.

In February a Joint meeting with the Grantham Engineering Society was held at Grantham, when Mr. J. Milwain, M.I.Prod.E., gave a Paper entitled "Production and Inspection of Gears". This meeting was very well attended.

No further meeting of the British Productivity Council in this Region has been called since the Inaugural meeting was held in June.

London

The quarter, January to March, 1954, contained five lecture meetings. The final meeting, "Building Large Turbo-Alternators" by Mr. J. R. Cotterill of the G.E.C. Ltd., was one in the series dealing with work not ordinarily done in the London area.

The Section Annual General Meeting was held at the same time as this last lecture meeting. The four retiring Committee members, Messrs. F. G. S. English, C. E. A. Griffin, R. Kirchner, and G. C. J. Legg have been re-elected, together with three new members, Messrs. J. R. Kelly, S. Kirk, and W. G. Marsden. Mr. R. E. Leakey was elected Section Chairman, and Mr. R. Hutcheson, Section Hon. Secretary.

The Annual Dinner held on 17th February was extremely successful, the guests of the Section being Sir Walter Puckey, Mr. G. R. Pryor, Mr. W. F. S. Woodford, and Mr. S. Caselton. The attendance was up to standard and a feeling of satisfaction for an excellent evening was expressed by all who attended.

A request for an Institution representative on an Engineering Advisory Committee to the Board of Governors of Brighton Technical College was responded to, and Mr. R. W. Tuck has undertaken this.

London Graduate

At the Annual General Meeting, Messrs. J. Clarke and F. Rutter retired from the Committee and Messrs. J. Hyland, A. Bowery and W. Bull were elected. Mr. R. Mustard retired, having served two years as Chairman, and Mr. F. Johns was elected in his place.

Section members continue to serve on the Hazleton Memorial Library Main and Sub-Committees.

The Tooling Study Group continues its study of tool design problems further to its recently published report on operating times of common jig and fixture components.

Lecture attendances this Session have been good and greater than in previous years.

Luton Graduate

In January the Section were fortunate to have Mr. C. H. Jackson to talk on "Air Transport as a Production Problem". This lecture was followed by one entitled "The Rise of the Trade Unions", which provoked a very interesting discussion.

At the "Graduates' Evening" held in March, the Senior Section President presented his prize to both Graduates who delivered short talks on "The Redux Process" and "Fibreglass" respectively during the evening, the prize being shared equally between them.

Visits have been made during this quarter to Enfield Cables Ltd., and its associated company, Enfield Rolling Mills, where a party of Graduates and Students saw the manufacture of many types of electrical cables, from crude copper cake to covered cable; also to Acton Bold Ltd., and to Sogenique (Service) Ltd.

Manchester

The Annual Section Dinner was held in February and the Section had the pleasure of having the President, Sir Walter Puckey, and the Lord Mayor of Manchester as Guests of Honour. The function was well attended and the response has encouraged the Committee to consider a similar function for next year.

A preliminary meeting of representatives of the four Sections constituting the North West Region has been held.

Manchester Graduate

The Annual General Meeting of the Graduate Section was held in March when three new committee members were elected, namely, Mr. V. J. Crowsley, Mr. R. A. Jones, and Mr. H. Moore. The Committee thanked the retiring members, Mr. Armes and Mr. Cleary, who have both served the Section in various offices for considerable periods.

The Chairman and Secretary attended the Fourth Annual Graduate Conference in Coventry in March. Their main contribution was to open the discussion on "Fully Exploring the Graduates' Position in the new Regional Reorganisation".

The Annual day visit has been arranged to take place at the works of Messrs. Sharp's Commercials Ltd., to be followed by a drive to Southport.

Melbourne

This last quarter being the summer period, the Section has been in recess until March. At the March meeting seventy-seven members and visitors attended a lecture on "Nut and Bolt Production by Cold Forging Methods" by Mr. Robert Clark, who has recently returned from an overseas visit to some of the world's largest nut and bolt manufacturers. The Paper was illustrated by slides and gave members an up-to-date review of the various processes used in the modern production of nuts and bolts.

A full and most interesting programme of lectures and works visits for 1954 has been arranged. The Melbourne Section is confident of a most successful year.

North Eastern

The last quarter has probably been the busiest and most successful so far as the activities of the North Eastern Section are concerned.

In January the Section had its first Paper on Shipbuilding, presented by Mr. F. T. Hunter. At the February meeting, Mr. Hallam gave a lecture on "Horizontal Boring". This meeting had the highest attendance of the session, and so great was the interest that the discussion had to be cut short by the Chairman.

At the request of the considerable number of Institution members resident on Tees-side, an extra February meeting was held at Middlesborough, when Mr. A. Cameron gave a repeat of his Institution Medal Paper: "Increased Productivity by Workshop Practice". The meeting, which was very well attended, had as its main purpose the question of exploring the possibility of starting a Tees-side Section within the North Eastern Region. After the Paper and discussion a temporary Tees-side Committee was formed to go fully into the question of the formation of this Section.

The Section held its Third Annual Dinner and Dance in February, when the Section was honoured by the presence of the President, Sir Walter Puckey, and the Secretary, Mr. Woodford. The principal guest was the Lord Mayor of the City of Newcastle-upon-Tyne, Alderman W. McKeag, and other distinguished guests were the Chairmen of the local Sections of the Institutions of Civil, Mechanical and Electrical Engineers.

In March one of the Committee members, Mr. Gaymer, gave a Paper entitled "Problems Involved in the Manufacture of Mineral Insulated Metal Covered Cables". Great interest was shown in this rather unique and interesting subject.

Norwich

At the January meeting one of the local members, Mr. V. Crowther, gave a most interesting lecture on "Gauge Making and Measuring" which was well attended. The Sub-Section broke new ground in February by holding a meeting in Yarmouth, when in spite of bad weather there was a good attendance for the film show which had been arranged. It is hoped to make this meeting a regular feature of future sessions.

In March the Chairman, Mr. G. Daniell, represented the Institution on a Management Brains Trust at a meeting organised by the Institute of Industrial Administration.

Nottingham

The Section Committee for the forthcoming session has been strengthened by the addition of Mr. C. T. Butler, B.Sc., Head of the Department of Engineering at the Nottingham and District Technical College, and Major Fleming, M.B.E., of the R.E.M.E. Workshops.

In order to increase attendance at lecture meetings and at the same time provide members with lectures in which the majority are interested, a questionnaire has been circulated throughout the Section. The member is asked to give three subjects on Production Engineering in which he is particularly interested, together with any other ideas he may have to brighten the meetings. The lecture programme for next session will be compiled from an analysis of the completed questionnaires. So far, the response has been very encouraging.

Oxford

Lecture meetings have been held each month during the period under review. Included in the programme have been original Papers on technical subjects, these being entitled "Glass Fibres and their use in Reinforced Plastics", and "Cold Forming of Light Alloys". Attendance at the meetings has continued on a fairly satisfactory level.

In view of the relatively high proportion of junior members in the Section, the Committee are giving considerable attention to Graduate activities.

The effect on the Section of the adoption by Council of the Regional Plan has given the Committee cause for considerable discussion. A further meeting has been arranged to take place shortly between the Reading, Southern and Oxford Sections' representatives, when the Regional Committee will be set up.

The period under review concluded with the holding of the Annual General Meeting in March, at which the retiring members of the Committee were re-elected, and Mr. F. S. Chappell, was added to their number. Mr. L. P. Coombes was re-elected as Chairman for the coming year, and Mr. M. J. Inston will continue as Section Hon. Secretary.

Peterborough

This quarter marks the end of the first full year of the activities of the Peterborough Sub-Section and the Committee are well pleased with the amount of interest which has been shown.

During the six lecture meetings held this Session there has been an average attendance of over sixty members and guests, and the Committee is quite confident that this attendance can be maintained.

The membership of the Sub-Section has shown an increase of 64 per cent. since this time last year.

Arrangements for the 1954/55 programme are well in hand and a number of prominent personalities in production engineering and other allied subjects have accepted the invitation to lecture to this Sub-Section.

Preston

At the Annual General Meeting held in March, Mr. E. G. Eaton was elected Section President and Mr. R. Thompson, Honorary Secretary, for the coming year.

The lecture programme for 1953/54 has been successfully concluded and it is interesting to note that the attendance of visitors to these lectures shows a marked increase on the previous year.

The Committee are taking an active part in obtaining representations to the various Local Productivity Committees which have been inaugurated in the Section and it is hoped that the Section can usefully contribute to the national scheme, having as its object an increase in productivity.

Reading

To enable lectures to be brought to dispersed areas this Section is proceeding to arrange lectures at Slough and Staines, as well as Reading and Basingstoke. This will come under the sphere of Reading under the Regional Plan.

The Committee have decided to arrange two Works Visits this summer. Previously only one a year has been arranged and all have been well supported.

Sheffield

The Section Committee have held a special meeting to consider the implications of the "Broadening the Base" Report and have sent forward their recommendations to the Membership Committee.

At the inaugural meeting of the Doncaster Sub-Section in February, Sir Walter Puckey gave an address to an audience of local industrialists and members and visitors.

The Section Annual General Meeting was held in March and Mr. E. Levesley was elected to the office of Chairman for 1954/55. The Regional Committee representatives have also been elected and the first meeting of this Committee is to take place very shortly.

The lectures during the season 1953/54 have been interesting and well attended. The Regional meeting held in February was addressed by Dr. T. E. Allibone, F.R.S.

Sheffield Graduate

Attendance at lecture meetings has shown an improvement during the present session and this is probably due to one or more of the changes which have been effected in the place and time of lecture meetings.

Committee elections for 1954/55 have taken place and Mr. E. Willcox was elected Chairman, and Mr. R. Ardron, Vice-Chairman. Mr. G. Shaw was re-elected Secretary. In accordance with past practice, the various Committee duties will be delegated, and a Student Representative will be co-opted. The present Chairman, Mr. C. G. Middleton, whilst eligible for re-election, stood down voluntarily to give the opportunity of chairmanship to other Committee members who would soon be due for transfer to another grade. It has now become an accepted custom for the Chairman of the Graduate Section to be elected to the Senior Section committee in a non-voting capacity. This gives him an opportunity to present the Graduate point of view when called upon and enables him to take advantage of the readily accorded advice and assistance of the senior members. When fixing the lecture details for 1954/55, the Committee have been able to call upon the information collected by the newly-appointed registrar, with regard to popular subjects, attendance statistics, etc.

Arrangements have been completed for the submission of Papers annually by Graduates to compete for a prize to be presented by the Sheffield Section President at the Annual General Meeting of the Section. Full details and rules will be circulated shortly.

South Africa

In February Mr. R. Blum delivered a Paper entitled "Some Applications of Statistics to Production Management". At the meeting held in March, Mr. C. O. Doehring spoke on "Production Engineering Problems of the Clothing Industry", supplemented by a film.

A visit to the works of Messrs. Scaw Alloys Limited in January, arranged jointly with the Institute of British Foundrymen, was attended by approximately forty-five members.

The published report of a Work Study Symposium will be available for distribution in the near future.

South Wales and Monmouthshire

The quarter under review saw the termination of the lecture programme, the occasion being a joint meeting with the Institute of Cost and Works Accountants in March, when a lecture on "The Relationship between Factory Administrative Procedure and Financial Control" was given by Mr. W. Crosskey, F.C.W.A. This stimulated a very interesting and instructive discussion, thoroughly enjoyed by a large audience.

Keen interest was shown in the series of special lectures devoted to the various aspects of production engineering, held at the Cardiff College of Technology. The attendance of many holding responsible technical positions in local concerns illustrates the growing reputation of the Institution amongst the industrial interests in the area.

With a view to encouraging closer collaboration, the Section President extended an invitation to Mr. Austin, Chairman of the South Wales East, and Mr. Bache, Chairman of the Treforest, Productivity Committees, to attend a joint meeting with the Section Committee. Both Mr. Austin and Mr. Bache outlined most eloquently the problems encountered since the formation of the committee. Following the discussion it was unanimously agreed to maintain a closer understanding of each other's activities, and with this in mind a small Liaison Committee was elected, to co-operate with and keep in close touch with the Chairmen of local Productivity Committees to further the objectives of the Productivity Council.

Stoke-on-Trent Sub-Section

The well attended lectures this quarter have been of a very high standard. Despite the adverse weather conditions there was a good attendance at the meeting in Crewe in January.

Two Graduate members attended the Fourth Annual Graduate Conference at Coventry.

At each of the three well-attended Committee meetings, much time has been spent discussing the constitutional arrangements of the new Regional Organisation. The Chairman and Hon. Secretary have attended a preliminary meeting at Manchester. At the Annual General Meeting two of the committee members were elected as representatives on the Regional Committee.

The Chairman, Mr. H. Porter, keeps the Committee well informed of the business of the Steering Committee of the local branch of the Productivity Council. It is hoped that a public meeting will be held in Stoke-on-Trent during May, as well as the lecture by Mr. Graham Hutton in April.

Sydney

Committee meetings were held in December and February with a good attendance of members. Mr. C. A. Gladman has been appointed to the Committee in place of Mr. C. E. Jones, who retired after many years of valuable service.

All members have been asked to encourage junior members of their staff to take Production Engineering Courses.

Before leaving for England, Mr. J. E. Hill, a Vice-President of the Institution, offered to take one Student per year for training at John Lund Ltd., of Keighley; this very generous offer has aroused considerable interest and will be a subject for discussion at the Australian Sub-Council meeting to be held in April.

Since the end of the 1952/53 Session, the Papers Committee have been preparing the lecture programme for the coming winter and the first Paper will be delivered in March by Mr. C. Houghton, on "Productivity and Work Study".

Western

The lecture programme for the last quarter has included a variety of subjects. In March a joint meeting was held with the Royal Aeronautical Society and was addressed by the President of the Institution, Sir Walter Puckey.

Wolverhampton Graduate

In January a very interesting lecture was given by Mr. H. Pearson, B.A.(Oxon.), on "Gear Cutting Procedure", illustrated by lantern slides. The January visit was made to the Quasi-Arc Ltd., Bilston, and a tour was made of the production departments and laboratory. In February a lecture was given by Mr. L. Hare, G.I.Mech.E., on "The Mechanical Gauging and Inspection of Machine Parts".

Also in February, a number of Students and Graduates made a tour of the company of Guy Motors Ltd., Wolverhampton.

The Tenth Annual General Meeting was held in March, followed by a very interesting lecture by Mr. G. W. Nicholls, A.M.I.Prod.E., M.I.B.F., on "Efficient Production Methods Applied to Ironfounding".

An interesting visit to Richard Thomas and Baldwins Ltd., of Stourbridge was made in March.

Yorkshire Graduate

In January an evening visit was made to Brooks Motors at Huddersfield. This was well supported by Graduates and visitors. A Paper was given in January by Mr. P. M. Goodchild, Grad.I.Prod.E., on "The Industrial Production of Oxygen". This Paper has won the Section President's Prize. In February another visit took place to Greenwood and Batleys, where members were shown a variety of products from forging to shell filling machines. In March, another Paper for the President's Prize, on "Special Machines to the Aid of Production" was given by Mr. R. Bailey, F.R.S.A.

The best wishes of the Section go with Mr. C. Wadsworth, who has left this Section to take up a post in Eire.

INSTITUTION NOTES

THE INSTITUTION YEAR BOOK, 1953/54

The Institution has now published its first Year Book and List of Members since 1946, and copies are being distributed to members. Non-members of the Institution may obtain copies of this publication, price one guinea post free, on application to the Secretary at 10, Chesterfield Street, London, W.1.

MATERIALS HANDLING CASE STUDIES

The attention of members is drawn to the Materials Handling Sub-Committee's request for assistance in the provision of case studies, which appears in the Supplement to this Journal.

It will be remembered that last year the Sub-Committee collaborated with the British Productivity Council in the production of a booklet of case studies, entitled " As The Spirit Moves ". The success of this publication confirms the Sub-Committee's belief that there is a real need for this type of information, and they are now drafting their own Report, in which they would like to incorporate similar case studies. Any assistance which could be rendered by members would be sincerely appreciated by the Sub-Committee.

SYMPOSIUM ON POWDER METALLURGY, 1954

The Iron and Steel Institute in association with the Institute of Metals is arranging a Symposium on Powder Metallurgy to be held in London on 1st and 2nd December, 1954, in Church House, Westminster, S.W.1.

On both days there will be morning and afternoon sessions for discussion of the Papers, which will cover both ferrous and non-ferrous aspects of powder metallurgy, and a small exhibition of powder metallurgy components is being prepared. The papers will be presented and discussed in the following main groups :—

I.—Metal Powders and their Assessment.

II.—Research and Production Practice.

III.—Production and Properties of Engineering Materials.

The Iron and Steel Institute has extended to members of the Institution of Production Engineers a cordial invitation to take part in the proceedings and anyone wishing to receive further particulars, the programme of the meeting and a form of application when available should write to the Secretary, Iron and Steel Institute, 4, Grosvenor Gardens, London, S.W.1, asking to be placed on the mailing list for this purpose.

MR. E. W. HANCOCK

The Institution is pleased to record that Mr. E. W. Hancock, M.B.E., who recently underwent a serious operation, is making a good recovery and is gradually resuming his duties as Director and General Manager of Humber Ltd.

MR. R. H. S. TURNER

Mr. R. H. S. Turner, Member, has been appointed Works Manager at the Trafford Park Works of Metrovick, Manchester. He joined the firm in 1930. Mr. Turner is Vice-President of the Manchester Section, and is also a corresponding member of the Papers Committee.

MR. R. G. WINTON

Mr. R. G. Winton, Associate Member, has been appointed to the board of Lansing Bagnall, Limited. He joined the firm seven years ago as Technical Manager. Before becoming Lecturer in Production Engineering at the Northampton Polytechnic and at Twickenham Technical College, Mr. Winton was with the London Passenger Transport Board. As the only British member of the O.E.E.C. of Materials Handling experts, he visited U.S.A., Canada and Europe to study Materials Handling Equipment and Methods.

Obituary

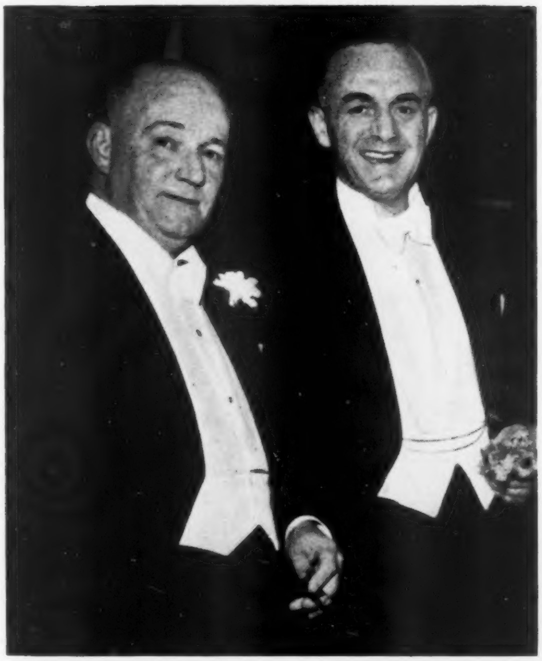
MR. J. A. HANNAY

The Institution records with deep regret the death of Mr. J. A. Hannay, a trustee and honorary member of the Institution.

Mr. Hannay had been a member of the Institution for twenty-seven years and was one of the pioneers responsible for its firm foundation and development in the early days. He was a founder member and the first President of the Birmingham Section, and later held office as Chairman of Council. During the whole of his membership Mr. Hannay worked untiringly to further the objects of the Institution, and at the April Meeting of Council, tribute was paid to the contribution he had made to its progress.

Mr. Hannay was Works Manager of The Austin Motor Company at the time Lord Austin was President of the Institution, but had been in retirement for many years. He will be sadly missed by his many friends and former colleagues.

The Birmingham Section Dinner Dance, held on 13th February, 1954, was as usual a well-attended and enjoyable function. The photograph above shows members and guests at dinner.



Two Past Presidents of the Birmingham Section attended the Dinner Dance—Mr. E. Percy Edwards (left), Member of Council, and Mr. J. France. Mr. Edwards, who is also a Member and Past Chairman of the Membership Committee, was recently appointed Joint Managing Director of his firm, The Lapointe Machine Tool Co. Ltd.

In the photograph below the Section President, Mr. Bernard Jackman (left), is obviously enjoying a chat with Professor T. U. Matthew, Member, Head of the Department of Engineering Production at the University of Birmingham.

Southern Section Dinner Dance

The Dinner Dance held by the Southampton Section of the Institution on 24th March, 1954, was a most successful function, and the Vice-President of the Section, Principal F. T. West (who was deputising in the absence through illness of the President, Mr. F. C. Cooke), is shown here with the principal guests. From left to right are Air Marshal Sir Hugh Walmsley, C.B.E., with Lady Walmsley; Mrs. F. T. West; Mr. S. Caselton, Assistant Secretary of the Institution, with Mrs. Caselton; Principal West; Mr. W. F. S. Woodford (Institution Secretary); the Deputy Mayor of Southampton, Councillor Mrs. M. Cutler, O.B.E., J.P.; Mrs. Woodford; Mr. Cutler; and Mr. N. J. Cottell (Past Section President) with Mrs. Cottell.

Mr. E. H. Davison, Member, has now relinquished his position as General Works Manager of India Galvanising Company and has taken up an appointment as General Manager of Hindustan General Electrical Corporation Limited and Barakar Engineering and Foundry Works Ltd.

Mr. A. G. Jennings, Member, has been appointed Works Manager of B.S.A. Tools Limited, Small Tools Division, Sparkbrook, Birmingham. Mr. Jennings joined the Company in 1917 as an apprentice and has been with B.S.A. Tools Limited for the whole of the 37 years, during which he has held several important positions. Prior to his recent appointment he was Plant Engineer to the B.S.A. Tools Group.

Chairman of Council Visits Canadian Section

During his recent visit to Canada the Chairman of Council, Mr. Harold Burke, visited the Canadian Section of the Institution. He is shown here with members of the Section Committee. From left to right are: Mr. C. E. Barkworth; Mr. Burke; Mr. P. M. Wood; Mr. W. M. Buchanan; Mr. R. E. Garner; Mr. C. J. Luby (Section Chairman); Mr. H. H. L. Ward; Mr. A. B. Bassett; Mr. A. W. Millward; Mr. L. R. Smith; and Mr. D. A. Jones.

NEW APPOINTMENTS

Mr. Harry D. Buller, Associate Member, has relinquished his position of Production Engineer with Messrs. Dennis Brothers, and has now taken up an appointment as Assistant to General Manager of Crossley Motors Limited, Stockport.

Mr. W. H. Cockerill, Associate Member, has now been appointed to the Board of Directors of Messrs. Castings Limited, Walsall.

Mr. W. J. Cumberland, Associate Member, has recently taken up a post with Lockheed Hydraulic Brake Co. Ltd., Leamington Spa, in the Extended Planning Dept., as Special Investigations Engineer.

Mr. F. T. Dean, Member, has recently been elected Chairman of the B.S.I. Committee on Overhead Runways and Conveyors.

Mr. G. L. A. Draper, Associate Member, has relinquished his post as Production Engineer with Newman Industries Limited, and has now taken up an appointment as Production Engineer with Messrs. Crompton Parkinson Limited at their Doncaster Works.

Mr. R. Gore, Associate Member, has been appointed Works Manager of Sheepbridge Equipment Limited, which is within the Sheepbridge Engineering Group.

Mr. H. P. Halfter, Associate Member, has recently been promoted Electrical Engineer within Her Majesty's Colonial Engineering Service, and is now holding the appointment of Head of the Electrical Engineering Department of the Gold Coast Railway and Harbour Authority.

Mr. T. L. Isaacs, Associate Member, has now joined the Glacier Metal Company, No. 3 Factory, Kilmarnock, as a Product Engineer.

Mr. John Hill, Associate Member, has recently been appointed Head of the Engineering Department at Barnoldswick Technical Institute, in the Craven Division of the West Riding of Yorkshire.

Mr. A. G. Jones, Associate Member, has been promoted from Bendigo Ordnance Factory and is now the Supervising Engineer, Aeronautical Research Laboratories (Commonwealth of Australia Department of Supply).

Mr. M. A. Latif, Associate Member, recently relinquished his appointment as an Assistant Professor and Lecturer in Mechanical Engineering at the Punjab College of Engineering and Technology and has now taken up the position of Production Engineer, in the Industrial Survey Team of Pakistan, under the Ministry of Defence.

Mr. H. P. Mott, Associate Member, has been appointed Materials and Production Controller with Lansing Bagnall Limited. Mr. Mott was formerly with Vauxhall Motors. He is Chairman of the recently formed Institute of Materials Handling.

Mr. W. T. White, Associate Member, has recently resigned his position with Standard Motor Company and has taken up a position as Production Engineer in the New Development and Process Department of the English Electric group of Companies.

Mr. W. G. Wyman, Associate Member, has taken up an appointment as Engineer to the Ulster Farm By-Products Limited.

Mr. A. L. Cole, Graduate, has taken up a position with English Electric Company, Navigational Projects Division, Luton, as a Project Engineer.

Mr. R. J. Currie, Graduate, has recently taken up an appointment as Engineer III in the Inspection Branch of the Division of Atomic Energy (Production), Risley.

Mr. A. J. Ellis, Graduate, has taken up a position as Test Engineer in the Research, and Development Department of Davey, Paxman and Co. Ltd., Colchester.

Mr. J. W. J. Finch, Graduate, has recently taken up a position as Sales Engineer, Gear Group, at the Birmingham office of The David Brown Corporation (Sales) Limited.

Mr. R. A. Foley, Graduate, has been appointed Chief Draughtsman of the M.O. Valve Co. Ltd.

Mr. D. J. I. Gray, Graduate, has recently taken up a position as Works Manager, at Christchurch Head Office Factory of Messrs. Booth Macdonald & Co. Ltd.

Mr. P. Henton, Graduate, has recently taken up a position as Design Engineer with Republic Aviation, New York.

Mr. M. W. G. Lewis, Graduate, has taken up an appointment as a Production Planning Engineer with Messrs. Redifon Limited.

Mr. P. F. Lewis, Graduate, has recently left this country to take up a position as Assistant Production Manager to Indian Aluminium Co. Ltd., Calcutta.

Mr. G. H. Newton, Graduate, has taken up an appointment as Product Development Engineer, Meter & Relay Works, English Electric Co., Stafford.

Mr. S. W. Orr, Graduate, has taken up a position as Methods Engineer, with Messrs. Young Accumulator Co. Limited.

Mr. R. D. Saha, Graduate, has recently taken up a position as Tool Designer with Briggs Car Bodies Limited, Dagenham.

Mr. G. Shaw, Graduate, is engaged as a Production Engineer in training at The Wireless Telephone Co. Ltd., Sheffield.

Mr. H. F. Sturt, Graduate, has recently taken up an appointment as a Management Trainee with the Michelin Tyre Co. Ltd.

Mr. B. R. Westwell, Graduate, has now been appointed to the post of Chief Engineer, Barclay & Fry Branch of the Metal Box Company Limited.

NEW BUILDING FUND APPEAL

Since the publication of the last list, donations have been received from the following subscribers. (The list was compiled for press on 21st May, 1954.)

H. W. Barnes, A.M.I.Prod.E.
E. Barrs, M.I.Prod.E.
V. S. Bhargav, Stud.I.Prod.E.
R. W. Brocklehurst, M.I.Prod.E.
W. Buchanan, M.I.Prod.E.
E. H. Y. Burden, M.I.Prod.E.
R. S. Clark, A.M.I.Prod.E.
W. T. Christie, M.I.Prod.E.
H. Davies, M.I.Prod.E.
A. V. Day, A.M.I.Prod.E.
W. J. Dimmock, A.M.I.Prod.E.
L. R. Evans, M.I.Prod.E.
A. D. Fogg, Grad.I.Prod.E.
D. S. Gardner, M.I.Prod.E.
H. Gardner, M.I.Prod.E.
L. W. W. Gibson, A.M.I.Prod.E.
A. E. Gosling, A.M.I.Prod.E.
G. W. Hand, M.I.Prod.E.
A. S. Hawtin, M.I.Prod.E.
R. W. P. Johnson, A.M.I.Prod.E.
H. A. Kench, M.I.Prod.E.
H. Kirkman, M.I.Prod.E.
H. M. Lawson, A.M.I.Prod.E.
J. Lonsdale, M.I.Prod.E.
P. Lloyd-Jones, A.M.I.Prod.E.
W. H. Marley, A.M.I.Prod.E.
J. McCluskey, M.I.Prod.E.
C. L. McCombie, A.M.I.Prod.E.
J. M. Moseley, Stud.I.Prod.E.
D. Millar, Grad.I.Prod.E.
W. C. Murray, A.M.I.Prod.E.
S. H. Pearson, M.I.Prod.E.
H. J. Roake, A.M.I.Prod.E.
S. R. Rose, A.M.I.Prod.E.
J. W. L. Russell, A.M.I.Prod.E.
A. C. Sharp, Stud.I.Prod.E.
A. J. H. Stevens, M.I.Prod.E.
H. C. Stewart, Grad.I.Prod.E.
R. Taylor-Thomas, A.M.I.Prod.E.
M. C. Timbury, M.I.Prod.E.
C. Timms, M.I.Prod.E.
H. W. Townsend, M.I.Prod.E.
G. W. Whitworth, A.M.I.Prod.E.
J. R. Widdowson, M.I.Prod.E.
M. A. White, A.M.I.Prod.E.
C. Windle, A.M.I.Prod.E.
J. R. Young, A.M.I.Prod.E.

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Members are asked to note that the Library will normally be open between 10 a.m. and 5.30 p.m. from Monday to Friday each week. It would be helpful if, in addition to the title, the author's name and the classification number could be quoted when ordering books.

Members are reminded that the Library service is available to all members of the Institution, and the Librarian is always willing to assist with enquiries.

REVIEWS

621.18 BOILERS

Technical Report. New series, Vol. 1. *British Engine Boiler & Electrical Insurance Company Ltd., Manchester. Manchester, the Company,* 1952. 212 *pages. Illustrations. Diagrams.* 12/6d.

The report is presented by the Company in order to help advance the standard of reliability of engineering plant, and is composed of the results of investigations into many causes of plant failure.

Suitable examples have been chosen and subjected to mechanical, metallurgical and chemical analysis in order to determine the causes of failure. Cases considered include caustic cracking, shell cracking and rivet failures in boilers, fractures of crane hooks and eye-bolts, defects in electrical machinery and the explosion of an air vessel. A chapter is devoted to sources of error in impact notched-bar testing.

The Company maintains a large laboratory using modern techniques and the treatment given to each case is very extensive and exacting. B.H.J.

621.7 PRODUCTION METHODS

" Fabricated Materials and Parts " by Theodore C. Dumond. *New York, Reinhold Publishing Corporation,* 1953. 332 *pages. Illustrations. Chart.* £2. 12. 0.

The author is the Editor of the technical periodical, " Materials and Methods ", doubtless already known to some readers, and this book had its origin in an article " Fabricated Materials and Parts—A Comparison of Their Design and Production Factors ", contributed by him to the periodical. The very favourable reception accorded it has encouraged Mr. Dumond to extend the same treatment to a much wider range of processes and the result is a textbook making an original contribution in this field.

The scope of the book may be conveniently summarised from the chapter headings: Sand, Permanent Mold, Plaster Mold, Die and Investment Casting; Drop, Press and Upset Forging; Cold Heading; Stamping and Pressing; Impact Extrusions; Extruded Shapes; Powder Metal Parts; Sectioned Tubing; Welded, Brazed and Adhesive Bonded Parts; Molded Plastics; Formed Non-metallic Parts.

It is not intended that the information given should deal comprehensively with the technology of the above methods; the aim is, " to bring together in one place in easy-to-read form, all of the important information which must be considered in deciding what methods of production best meet the needs of the individual making the choice ".

Three introductory chapters analyse factors which influence the choice of production method. A sensible balance is kept between the design factors of strength, weight, tolerance and surface finish and economic factors of quantities, labour costs, tool costs, time to get into production, rate of production. It is indicative

of the quality of this book that relationships of this complexity can be handled with reasonable thoroughness in thirty-one pages.

The remainder of the book, twenty chapters, is devoted to the production techniques previously enumerated. Each chapter treats one process, giving a brief but lucid account of the method, and discussing relevant economic and design points upon which decisions must be made regarding its suitability under known circumstances. The liberal photographic illustrations are instructive, adding considerably to the clarity of the book, and some useful data is given in tabular form; e.g. page 151, "Typical Materials for Cold Headed Parts". A tabular summary of the twenty processes, in folder form, is attached to the rear cover.

It is obvious that the author has had the assistance of industrial concerns, specialising in the various processes, which have seized this opportunity to present the particular merits of their activities. By a strictly factual presentation the author has avoided suggestions of sales pushing which sometimes mar such co-operation. The assisting firms are to be complimented on allowing such a wealth of material to be set out so impartially.

This book has its disturbing side. Can American industry get into production as quickly as is shown on page 30, e.g. "Die casting, several days to several weeks"? Do Americans go so thoroughly into production factors before getting out designs? Is there room for a British counterpart to this book with data drawn from our own industries? Does it throw a new light on Materials Utilisation? This is a book to raise, as well as answer, many questions. A.J.L.

OTHER ADDITIONS

658.54 TIME AND MOTION STUDY

Time Study and Methods Conference, No. 8. *New York,* 1953. **"Proceedings [of the] . . . Conference sponsored by Society for Advancement of Management and the American Society of Mechanical Engineers' Management Division."** *New York, Society for Advancement of Management,* 1953. 124 *pages. Diagrams.* £2. 2. 0.

Stevenson, Jordan & Harrison Ltd., *London.* **"Production Standards from Time Study Analysis by Labour and Management."** *London, the Firm,* 1944. 111 *pages. Charts.*

Gilbreth, Frank Bunker, *and Gilbreth, Lilian Moller.* **"Applied Motion Study."** *London, Routledge,* 1919. 220 *pages. Illustrated. Charts.*

621.777 SHEET METAL WORK

Schuler, L., A.G., *Goeppingen, Germany.* **"Handbook for Economical Sheet Metal Working and Pressing."** Third enlarged edition. *Coventry, A. C. Wickman Ltd.,* 1937. 434 *pages. Illustrated. Diagrams.*

621.778 WIRE DRAWING AND PROCESSING

Wire Industry Encyclopaedic Handbook to the Wire Drawing and Wire Fabricating Industry. *London, Wire Industry Ltd.,* 1953. 448 *pages. Illustrated. Diagrams.* £1. 1. 0.

621.78 HEAT TREATMENT

Reynolds Metals Company, *Louisville, Ky.* **"Heat Treating Aluminium Alloys."** *Louisville, the Company,* 1948. 144 *pages. Illustrated.* $1.00.

SHELL MOULDING

A Select Bibliography of Literature in the Library

A. NON-PERIODICAL PUBLICATIONS

Bakelite Company, New York. **"Phenolic Resins for Foundry Molds and Cores."** *New York, the Company,* 1951. 20 *pages. Illustrated.*

Bakelite Ltd., London. **"Resins for Shell Moulds and Cores."** *London, the Firm* [195—]. 8 *pages. Illustrated.*

British Brassfoundry Productivity Team. **"The Brassfoundry: Report of a visit to the U.S.A. in 1950."** *London, Anglo-American Council on Productivity for the team,* 1951. *Pages* 119-125, Synthetic Resin Core Binders, with special reference to the "C" process.

Field Information Agency Technical. Final Report No. 1168. **"The 'C' Process of making Molds and Cores for Foundry use."** *London, H.M.S.O.* 1947. 1/3d. Out of print.

Leicester, Lovell & Co. Ltd., Southampton. **"Thor Resins for Shell Moulds and Cores."** *Southampton, the Firm* [1953]. 12 *pages.*

Marotta, A. J. **"Shell Molding Process and Magnesium Castings."** *New York, Magnesium Association,* 1952. 8 *pages. Illustrated.*

Monsanto Chemical Company—Plastics Division. **"The Shell Molding Process: a new and proved method for the Foundry Industry."** *Springfield, Mass., the Company,* 1952. 28 *pages. Illustrated. Charts.* (Production Information Bulletin No. 77).

"Shell Moulding." Brighton, Machinery Publishing Co. Ltd., 1953. 84 *pages. Illustrated.* 4/-. (Machinery's Yellow Back Series No. 34).

Union Carbide and Carbon Corporation, Bakelite Division, New York. **"Bakelite Phenolic Resins for the 'Croning' Process."** *New York the Corporation,* 1950. 15 *pages. Illustrated.*

U.S.A.—Dept. of Commerce—Office of Technical Services. **"Current Status of the Shell-Mold or the 'C' Process of Precision Casting Metals [1952]."** 16 *pages.* (IR—7734. PB—106640).

B. PERIODICAL ARTICLES

I. General Surveys.

AIRCRAFT ENGINEERING 22 : 371-374, Dec. 1950. Perry, H. W. An improved casting process with resin-sand moulds : some details of a new method evolved by the Bakelite Corp. from the Johannes Croning system.

AIRCRAFT ENGINEERING 25 : 151, May 1953. Shell mouldings—a new foundry technique : a brief account of developments in the production of castings since the introduction of synthetic materials.

AIRCRAFT PRODUCTION 15 : 48-9, Feb. 1953. Shell moulding : rapid production of resin-bonded sand moulds and cores. (Polygram Casting Co. Ltd.).

AUTOMOBILE ENGINEER 43 : 65-69, Feb. 1953. Shell moulding : an important foundry development. (Polygram Casting Co. Ltd.).

BRITISH PLASTICS 25 : 414-5, Dec. 1952. Shell moulding process (*in* article Synthetic resins in the foundry, by D. N. Buttrey).

BRITISH PLASTICS 26 : 14-18, Jan. 1953. Some features of the shell moulding process (Bakelite Ltd., and Polygram Casting Co. Ltd.)

BUSINESS 83 : 96-98, Feb. 1953. Casey, F. G. This process promises every foundry lower costs, every firm its own foundry.

ENGINEER AND FOUNDRYMAN 17 : 81, Jan. 1953. Shell moulding. (Polygram Casting Co. Ltd.)

FOUNDRY TRADE JOURNAL 90 : 281-284, Mar. 15, 1951. The " C " process. (Bakelite Division, Union Carbide and Carbon Corporation).

FOUNDRY TRADE JOURNAL 93 : 647-650, Dec. 4, 1952. Shell moulding developments (Polygram Casting Co. Ltd.). *Correspondence* : 93-694, Dec. 18, 1952. J. A. F. Jarvis. 94 : 118, Jan. 29, 1953. J. Fallows.

FOUNDRY TRADE JOURNAL 94 : 97, Jan. 22, 1953. Shell moulding and the plastics industry. (Bakelite Ltd.).

FOUNDRY TRADE JOURNAL 94 : 355-364, Mar. 26 ; 385-387, April 2, 1953. Dixon, M. C., and Bushnell, R. S. The " C " process of casting ; [with] Discussion.

FOUNDRY TRADE JOURNAL 95 : 531-536, 541-547, Oct. 29, 1953. Buttrey, D. N. Shell moulding process [with] Discussion. *Similarly in* Engineering 176 : 251-252, Aug. 21, 285, Aug. 28, 1953. *Abstract in* Metal Industry 83 : 12-13, July 3, 1953.

FOUNDRY TRADE JOURNAL 96 : 323-328, Mar. 25, 1954. Pentz, P. G. Recent developments with synthetic resins in the foundry industry. *Abstracts in* Engineering 177 : 404-5, Mar. 26, 1954 ; Machinery 84 : 563, Mar. 12, 1954.

IRON AND COAL TRADES REVIEW 168 : 93-95, Jan. 8, 1954. Progress in shell moulding : simplified layout to give increased output. (Fairbairn Lawson Combe Barbour Ltd., Leeds).

MACHINE SHOP MAGAZINE 13 : 561-566, Dec. 1952. Development in the shell moulding process (Polygram Casting Co. Ltd.).

MACHINERY (London) 81 : 1111-1116, Nov. 28, 1952. The shell moulding process : methods employed by Polygram Casting Co. Ltd., Chiswick.

MACHINERY (London) 81 : 1293, Dec. 19, 1952. Comparative costs of shell and sand moulding.

MACHINERY (London) 82 : 155-157, Jan. 23, 1953. Some recommendations for shell moulding (Monsanto Chemical Co.).

MACHINERY (London) 82 : 448-9, Mar. 6, 1953. Production of cores by a shell moulding process (patent, Stanton Ironworks Co. Ltd.).

MACHINERY (London) 84 : 501-505, Mar. 5, 1954. The Fordath D-process : a new method of producing shell moulds (Fordath Engineering Co., West Bromwich).

MACHINERY LLOYD. European edition. 25 : 57-63, May 2, 1953. Sargeaunt, M. J. Shell moulding. *The same*:—Machinery Lloyd Overseas ed. 25 : 80-84, Feb. 14, 1953.

MACHINIST 96 : 1927-1931, Nov. 29, 1952. Fallows, J. British firm goes ahead with shell moulding process (Polygram Casting Co. Ltd.).

MASS PRODUCTION 29 : 82-87, Feb. 1953. Large scale production by shell moulding.

MECHANICAL WORLD AND ENGINEERING RECORD 133 : 22-23, Jan. 1953. Shell moulding.

METAL INDUSTRY 81 : 441-444, Dec. 5, 1952. Shell moulding : the process as it affects non-ferrous castings.

METAL TREATMENT AND DROP FORGING 21 : 57-60, Feb. 1954. Progress in shell moulding : increasing use as a production unit (Fairbairn Lawson Combe Barbour Ltd., Leeds).

TOOL ENGINEER 28 : 53-56, June 1952. Herold, R. Shell molding by the Croning process.

TOOL ENGINEER 31 : 126, July 1953. Sololosky, W. Pros and cons of shell molded castings.

TOOLMAKER & PRECISION ENGINEER 7 : 12-16, Jan. 1953. Developments in the shell moulding process.

II. Possibilities and Limitations : Experience of Users.

AIRCRAFT PRODUCTION 15 : 103, Mar. 1953. Shell moulded castings : alloys used by the Solar Aircraft Foundry.

AMERICAN MACHINIST 95 : 126, Oct. 15, 1951. Shell molding produces precise big castings.

ENGINEER & FOUNDRYMAN 17 : 53, 55, Mar. 1953. Steele, J. Modern moulding methods . . . shell moulding process.

FOUNDRY TRADE JOURNAL 92 : 613, 618, June 12, 1952. In a nutshell : [editorial].

FOUNDRY TRADE JOURNAL 95 : 7-14, July 2 ; 53-59, July 9 ; 87-95, July 16; 541-547, Oct. 29, 1953. Ames, B. N. Survey of the shell moulding method of casting production [with] Discussion. *Abstracts in* Machinery (London) 83 : 1106-1110, Dec. 4, 1953 ; Metal Industry 83 : 13, July 3, 1953.

FOUNDRY TRADE JOURNAL 95 : 79-80, July 16, 1953. Shell moulding patterns and possibilities : impressions from the Congress of the American Foundrymen's Society.

FOUNDRY TRADE JOURNAL 95 : 591-593, Nov. 12, 1953. McGavock, H. K. Mechanised shell moulding plant (Lynchburg Foundry Co., Lynchburg, Va.).

FOUNDRY TRADE JOURNAL 95 : 687-696, Dec. 3, 1953. Emmerson, A. Shell moulding of cylinder castings. *Discussion.* 96 : 13-18, Jan. 7, 1954.

FOUNDRY TRADE JOURNAL 95 : 745-747, 759, Dec. 17, 1953. Hand, C., and Beeley, P. R. Application of shell moulding to steel castings.

FOUNDRY TRADE JOURNAL 95 : 783-785, Dec. 24, 1953. Potter, C. Practical experience of shell moulding.

INSTITUTION OF PRODUCTION ENGINEERS JOURNAL 32 : 577-580, Dec. 1953. Rigg, L. Shell moulding.

IRON AGE 168 : 111-116, Nov. 15, 1953. Calder, A W. Jobbing foundry adopts C-process for making shell moulds. *Abstract in* Foundry Trade Journal 91 : 739, Dec. 27, 1951.

IRON AGE 168 : 120-121, Nov. 15, 1951. Brown, D. I. Resin makers push Croning process.

IRON AGE 169 : 28, Jan. 24, 1952. C-process : some details revealed (Auto Specialities Mfg. Co.).

IRON AGE 169 : 109-113, May 15, 1952. Derby, G. P. Job foundry tackles shell mold production (Lynchburg Foundry Co.).

IRON AGE 169 : 118-120, May 15, 1952. Shell molding steals foundry show.

IRON AGE 169 : 112-116, June 26, 1952. Sullivan, G. F. Shell molded stainless valves and fittings now in production (Cooper Alloy Foundry).

IRON AGE 170 : 172-174, Dec. 11, 1952. Design and production of shell mold patterns improved (Wolverine Pattern and Mfg. Co.).

IRON AGE 171 : 298-299, Jan. 1, 1953. Shell molding and continuous casting revolutionize output of many types of metal parts. *Comment in* Trade Journal 94 : 173, Feb. 12, 1953.

IRON AGE 171 : 80-81, May 14, 1953. Foundrymen—focus on shell molding.

IRON AGE 171 : 148-154, May 21, 1953. Continued wide interest in shell molding shown at AFS meeting.

IRON AGE 171 : 154-157, June 18, 1953. Shroka, H. S. Where does shell molding fit in your parts picture ?

IRON AGE 172 : 124-128, July 23, 1953. Heath, R. V. Complex aluminium part successfully shell molded.

IRON AGE 172 : 128-132, Sep. 3, 1953. Von Ludwig, D. Part needs determine best casting method.

IRON AGE 173 : 55-57, Jan. 28, 1954. Shell molding brings new foundry era (Walworth Co., Boston).

MACHINE DESIGN 23 : 239-240, Dec. 1951. Ames, B. N. Shell molding.

MACHINE DESIGN 24 : 160-162, Sep. 1952. Bolz, R. W. Shell molding.

MACHINERY (London) 80 : 882, May 22, 1952. The Shell-moulding process [editorial].

MACHINERY (London) 81 : 1030-1032, Nov. 14, 1952. Casting stainless steel in shell moulds (Cooper Alloy Foundry Co., N.J.).

MACHINERY (London) 82 : 419-426, Mar. 6, 1953. Producing high-quality iron castings in shell moulds : methods employed by Macmillan Foundries Ltd., Watford.

MACHINERY (London) 82 : 475-480, Mar. 13, 1953. Making Coronation bells in shell moulds (Gillett & Johnson Ltd., Croydon).

MACHINERY (London) 82 : 1041-1048, June 5, 1953. Making light alloy castings in shell moulds : techniques employed at Lightalloys Ltd., London, N. W.10.

(a) MACHINERY (London) 83 : 808-809, Oct. 23, 1953. Stainless-steel castings made in shell moulds (Langley Alloys Ltd., Slough, Bucks.).

MACHINERY (London) 83 : 1014, Nov. 20, 1953. Some examples of shell moulds shown at Olympia.

(a) MACHINERY (London) 83 : 180, July 24, 1953. High quality iron castings made in shell moulds (John Harper & Co., Willenhall, Staffs.).

MACHINERY (London) 83 : 1069-1070, Nov. 27, 1953. Shell moulds for magnesium castings (publication PB111049, T.I.D.U.

MACHINERY (London) 83 : 1186, Dec. 18, 1953. Progress in shell moulding [editorial].

MACHINERY (London) 84 : 211-217, Jan. 29, 1954. Casting agricultural machinery gears in shell moulds (Blackburn & Sons Ltd., Preston, Lancs.).

MACHINERY (London) 84 : 378-379, Feb. 19, 1954. Some examples of non-ferrous castings produced in shell moulds (Starling Foundries Ltd., Croydon).

MACHINERY (London) 84 : 366, Feb. 19, 1954. The " D " shell mould process [editorial].

MACHINERY (New York) 60 : 186-195, Nov. 1953. Smith, J. H. Shell-mold castings of automotive parts.

MACHINERY LLOYD. Overseas edition. 26 : 71-80, Mar. 13, 1954. Sargeaunt, M. J. Shell moulding in action (Fairbairn Lawson Combe Barbour Ltd., Leeds).

MACHINIST 96 : 2049-2056, Dec. 20, 1952. Hollingum, J. Automatic shell moulding.

MACHINIST 98 : 188-190, Jan. 30, 1954. Shell moulding steel castings (Sheepbridge Steel Castings Ltd., Notts.).

MATERIALS & METHODS 37 : 73-77, Jan. 1953. Rose, K. Where shell mold castings stand today.

MATERIALS & METHODS 39 : 102-104, Feb. 1954. Curry, T. W. One company's experience with shell mold castings (Lynchburg Foundry Co.).

METAL INDUSTRY 81 : 206-207, Sep. 12, 1952. Dunlop, A. Casting developments . . . the " C " process.

MILL & FACTORY 52 : 120, Feb. 1953. Small intricate castings produced at low cost (Solar Aircraft Co., San Diego).

PRECISION METAL MOULDING 11 : 32-33, 74, July 1953. Shell molding *vs.* conventional sand casting—some dramatic cost comparisons.

PRECISION METAL MOLDING 12 : 44-45, Feb. 1954. Big savings—3 case histories of shell mold castings (Builders Iron Foundry).

PRODUCT ENGINEERING 23 : 121-127, Oct. 1952. Shell molding saves through greater mechanization and less machining.

PRODUCT ENGINEERING 24 : 129-133, Sep. 1953. Dunn, W. H., and Day, R. E. Shell molding of stainless steel.

PRODUCT ENGINEERING Annual handbook of product design for 1954. D26-D29. Ames, B. N., *and others.* Survey of shell molding problems.

PRODUCT ENGINEERING 25 : 139-144, Mar. 1954. Beamer, P. W., and Tingquist, S. C. Evaluation of casting processes.

III. Resins, Sands, and Wetting and Stripping Agents.

ENGINEER 194 : 85-6, July 18, 1952. Synthetic resins for foundry use (Imperial Chemical Industries Ltd., Plastics Division).

ENGINEER 194 : 845, Dec. 19, 1952. Shell moulds and cores (Bakelite Ltd.).

ENGINEERING 174 : 87-88, July 18, 1952. Synthetic resins in the foundry (Imperial Chemical Industries Ltd., Plastics Division).

FOUNDRY TRADE JOURNAL 94 : 290, Mar. 12, 1953. Carswell, R. Synthetic resins in the foundry (abstract).

FOUNDRY TRADE JOURNAL 93 : 477, Oct. 23, 1952. " Shell " foundry moulds (Bakelite Ltd.).

IRON AGE 171 : 144-145, June 25, 1953. Shell molding : cheap sand may boost resin needs (Monsanto Chemical Co., Plastics Division).

MACHINERY (London) 80 : 1077-1078, June 19, 1952. Materials and equipment for shell moulding (Thor phenolic shell-moulding resin ; Borden's Chemical Division, New York).

MACHINERY (London) 81 : 922, Oct. 23, 1952. " Shell " foundry moulds (Bakelite Ltd.).

MACHINERY (London) 81 : 1240-1241, Dec. 12, 1952. Bakelite resins for shell moulds and cores.

MACHINERY (London) 82 : 337-338, Feb. 20, 1953. I.C.I. Mouldrite resin for shell moulding.

MACHINERY (London) 82 : 526-532, Mar. 20, 1953. Shell moulding with urea-formaldehyde resins (British Industrial Plastics Ltd., Oldbury).

MACHINERY (London) 82 : 549, Mar. 20, 1953. Cellobond resins for shell mouldings (British Resin Products Ltd.).

MACHINERY (London) 82 : 687-689, April 10, 1953. Thor resins for the production of shell moulds and cores (Leicester Lovell & Co. Ltd., Southampton).

MACHINERY (London) 82 : 763, April 24, 1953. Synphorm resins for shell moulding.

MACHINERY (London) 82 : 913, May 15, 1953. Redhill sands for the shell moulding process.

MACHINERY (London) 82 : 1024, May 29, 1953. Nestor shell moulding resins (James Ferguson & Sons Ltd., London)

MACHINERY LLOYD, European edition. 25 : 69-72, May 16, 1953. Synthetic resins for shell moulds and cores (Bakelite Ltd.) *The same in* Machinery Lloyd. Overseas edition. 25 : 96-98, Feb. 28, 1953.

METAL INDUSTRY 83 : 278, Oct. 2, 1953. Shell moulding economy (Thor resins Borden Co., New York).

TOOL ENGINEER 29 : 86, Sep. 1952. Dow shares know-how on parting agent problem with shell molding industry.

IV. Machines for Moulding and Coremaking.

(a) General

FOUNDRY TRADE JOURNAL 95 : 363, Sep. 17, 1953. " Dornal " *pseud.* Mechanization of shell moulding. *Correspondence* : 95 : 594, Nov. 12, 1953. P. J. Berry.

METAL INDUSTRY 81 : 206-207, Sep. 12, 1952. Dunlop, A. Casting developments . . . the " C " process.

TOOLMAKER & PRECISION ENGINEER 7 : 22-23, June 1953. Shell moulding machines in U.S.A.

(b) Single Station Machines

AIRCRAFT PRODUCTION 15 : 241, July 1953. Shell moulding : new British machine for fully automatic operation (Autoclino).

BRITISH MACHINE TOOL ENGINEERING 35 : 161-162, Oct.-Dec. 1953. Autoclino shell moulder.

BRITISH PLASTICS 26 : 315, Aug. 1953. Fully automatic shell moulding machine (Auto clino).

ENGINEER 195 : 859-860, June 19, 1953. An automatic shell mould making machine (Autoclino).

ENGINEERING 175 : 745, June 12, 1953. Automatic shell moulding machine (Autoclino).

FOUNDRY TRADE JOURNAL 94 : 351-352, Mar. 26, 1953. Shell moulding machinery (F.E.—Sutter).

FOUNDRY TRADE JOURNAL 94 : 600, May 28 ; 708, June 18, 1953. New shell moulding machine (Autoclino)

IRON AGE 167 : 81-85, April 19, 1951. Czygan, W. Machines make shell molds automatically (Shellmold & Machine Co., SU-1 machine).

IRON AGE 170 : 63, Aug. 21, 1952. Shell molds for job shops (Powdered Metal Products Corp.). *Abstract in* Foundry Trade Journal 93 : 414, Oct. 9, 1952).

MACHINE DESIGN 25 : 233, Jan. 1953. New equipment offered for shell moulding (Powdered Metal Products Corp.).

MACHINERY (London) 82 : 593-595, Mar. 27, 1953. F. E. (Sutter) automatic shell moulding machines.

MACHINERY (London) 82 : 1074-1076, June 5, 1953. Autoclino automatic shell mould making machine.

MACHINERY LLOYD Overseas ed. 25 : 95-97, Sep. 12, 1953. Mechanised shell moulding (Autoclino).

MASS PRODUCTION 29 : 78-80, Aug. 1953. Automatic shell moulder (Autoclino).

METAL INDUSTRY 82 : 502, June 19, 1953. Automatic shell moulding (Autoclino).

(*c*) *Two Station Machines*

FOUNDRY TRADE JOURNAL 95 : 730-732, Dec. 10, 1953. F.L.C.B. shell moulding equipment (Fairbairn Lawson Combe Barbour Ltd., Leeds).

FOUNDRY TRADE JOURNAL 96 : 311-312, Mar. 18, 1954. Fordath shell moulding machine (Fordath Engineering Co. Ltd., West Bromwich, Staffs.).

FOUNDRY TRADE JOURNAL 96 : 330, Mar. 25, 1954. Shelmolda Duplus (Fairbairn Lawson Combe Barbour Ltd., Leeds).

MACHINERY (London) 83 : 722-724, Oct. 9, 1953. Coleman-Wallwork shell mould making machine.

MACHINERY (London) 84 : 431-436, Feb. 26, 1954. Shelmolda shell mould making equipment of simple construction (Fairbairn Lawson Combe Barbour Ltd., Leeds).

MACHINERY LLOYD. Overseas ed. 26 : 71-80, Mar. 13, 1954. Sargeaunt, M. J. Shell moulding in action. (Fairbairn Lawson Combe Barbour Ltd., Leeds).

MACHINERY MARKET No. 2775, Jan. 22, 1954, p. 82. Shell moulding : small scale production units (Fairbairn Lawson Combe Barbour Ltd., Leeds).

MACHINIST 97 : 2167-2169, Dec. 26, 1953. New low-cost shell moulding equipment produces 40 shells per hour with one operator (Fairbairn Lawson Combe Barbour Ltd., Leeds).

MASS PRODUCTION 30 : 77-80, Feb. 1954. New shell moulding machine (Fairbairn Lawson Combe Barbour Ltd., Leeds).

MECHANICAL WORLD AND ENGINEERING RECORD 134: 20-21, Jan. 1954. Production shell moulding (Fairbairn Lawson Combe Barbour Ltd., Leeds).

POWER TRANSMISSION 23 : 66-68, Jan. 15, 1954. A New shell moulding unit (Fairbairn Lawson Combe Barbour Ltd., Leeds).

TIMES REVIEW OF INDUSTRY 8 : 53, Jan. 1954. Compact shell moulding equipment (Fairbairn Lawson Combe Barbour Ltd., Leeds).

(*d*) *Multi-Station Machines*

BRITISH PLASTICS 26 : 60-61, Feb. 1953. Shell moulding machine steps up foundry production (Polygram Mark IV).

ENGINEER 195 : 96-97, Jan. 16, 1953. Mechanised shell mouldings (Polygram Casting Co., Ltd.).

ENGINEERING 175 : 44-45, Jan. 9, 1953. Developments in shell moulding (Polygram automatic shell moulding machine).

FOUNDRY TRADE JOURNAL 94 : 31, Jan. 8, 1953. Quantity production of shell moulds : rotary machine developed by Polygram.

MACHINE SHOP MAGAZINE 14 : 87, Feb. 1953. Shell moulding plant (Polygram Casting Co. Ltd.).

MACHINERY (London) 82 : 87-88, Jan. 9 ; 126-127, Jan. 16, 1953. Polygram Mark IV shell moulding machine.

MACHINERY LLOYD. European edition. 25 : 98-99, Mar. 21, 1953. Mechanized shell moulding (Polygram Mark IV machine).

MACHINERY MARKET No. 2722, Jan. 16, 1953, p. 57. Mass production of shell moulds : a new automatic moulding machine (Polygram Mark IV).

MACHINIST 97 : 70-71, Jan. 10, 1953. Automatic shell moulding machine (Polygram Mark IV).

METAL INDUSTRY 82 : 52-3, Jan. 16, 1953. Mechanized shell moulding (Polygram automatic shell moulding machine Mark IV).

TOOLMAKER & PRECISION ENGINEER 7 : 36-37, Feb. 1953. Mechanised shell moulding (Polygram automatic shell moulding machine).

V. Clamping

ENGINEERING 176 : 296, Sep. 4, 1953. Pneumatic clamp for shell moulds (British Cast Iron Research Association).

FOUNDRY TRADE JOURNAL 94 : 97, Jan. 22, 1953. Shell-moulding and the plastics industry . . . clamping of shells superseded (Bakelite Ltd.).

FOUNDRY TRADE JOURNAL 95 : 371, Sep. 17, 1953. B.C.I.R.A. method of clamping shell moulds.

MACHINERY (London) 82 : 784-786, April 24, 1953. Beech, A. S. Method of registering, clamping, closing-up and supporting shell moulds.

MACHINERY (London) 83 : 98, 141, July 17, 1953. Closing and backing-up shell moulds (editorial).

MACHINERY (London) 83 : 469, Sep. 4 ; 958, Nov. 13, 1953. A new method of clamping shell moulds (British Cast Iron Research Association).

MACHINERY (London) 83 : 1186, Dec. 18, 1953. Progress in shell moulding [editorial].

MACHINERY (London) 84 : 227, Jan. 29, 1954. Coleman-Wallwork shell mould clamping device.

MACHINERY LLOYD. European edition. 25 : 95, Nov. 14, 1953. Clamping shell moulds (British Cast Iron Research Association). *The same in* Machinery Lloyd. Overseas ed. 25 : 85, Oct. 10, 1953.

(*a*) MASS PRODUCTION 29 : 118, 120, Sep. 1953. Clamping shell moulds (B.C.I.R.A.).

MECHANICAL WORLD AND ENGINEERING RECORD 133 : 388, Sep. 1953. New method of clamping shell moulds (B.C.I.R.A.).

METAL INDUSTRY 83 : 318, Oct. 16, 1953. Clamping shell moulds (B.C.I.R.A.).

(*a*) MACHINIST 97 : 1521, Sep. 12, 1953. Pneumatic clamp for shell moulding (B.C.I.R.A.).

VI. Patent Situation

FOUNDRY TRADE JOURNAL 93 : 238, Aug. 28, 1952. Shell moulding process (U.S. patent positions).

MACHINIST 96 : 2001, Dec. 6, 1952. Trefgarne, Lord. Shell moulding patents : Polygram Company's point of view. *Similarly in* Foundry Trade Journal 93 : 582, Nov. 20, 1952 ; Iron Age 171 : 99, Jan. 15, 1953.

PRODUCT ENGINEERING 23 : 113, 115, June 1952. Shell molding (U.S. patent position).

PRODUCT ENGINEERING 24 : 223, May, 1953. Shell molding cartel (the patent controversy).

C. BIBLIOGRAPHIES.

BRITISH CAST IRON RESEARCH ASSOCIATION—Bulletin and foundry abstracts. 11 : 280-283, July 1952. Shell moulding (Croning process) : a select bibliography.

PERA BULLETIN 6 : 609-611, Nov. 1953. Bibliography . . . shell moulding.

SHEFFIELD CITY LIBRARIES. Select bibliography on shell moulding practice (Croning or " C " process); [with] (Supplement). Sheffield, Science and Technology Library, 1952-3. 5 pages typescript. (Research bibliographies, new series No. 61).

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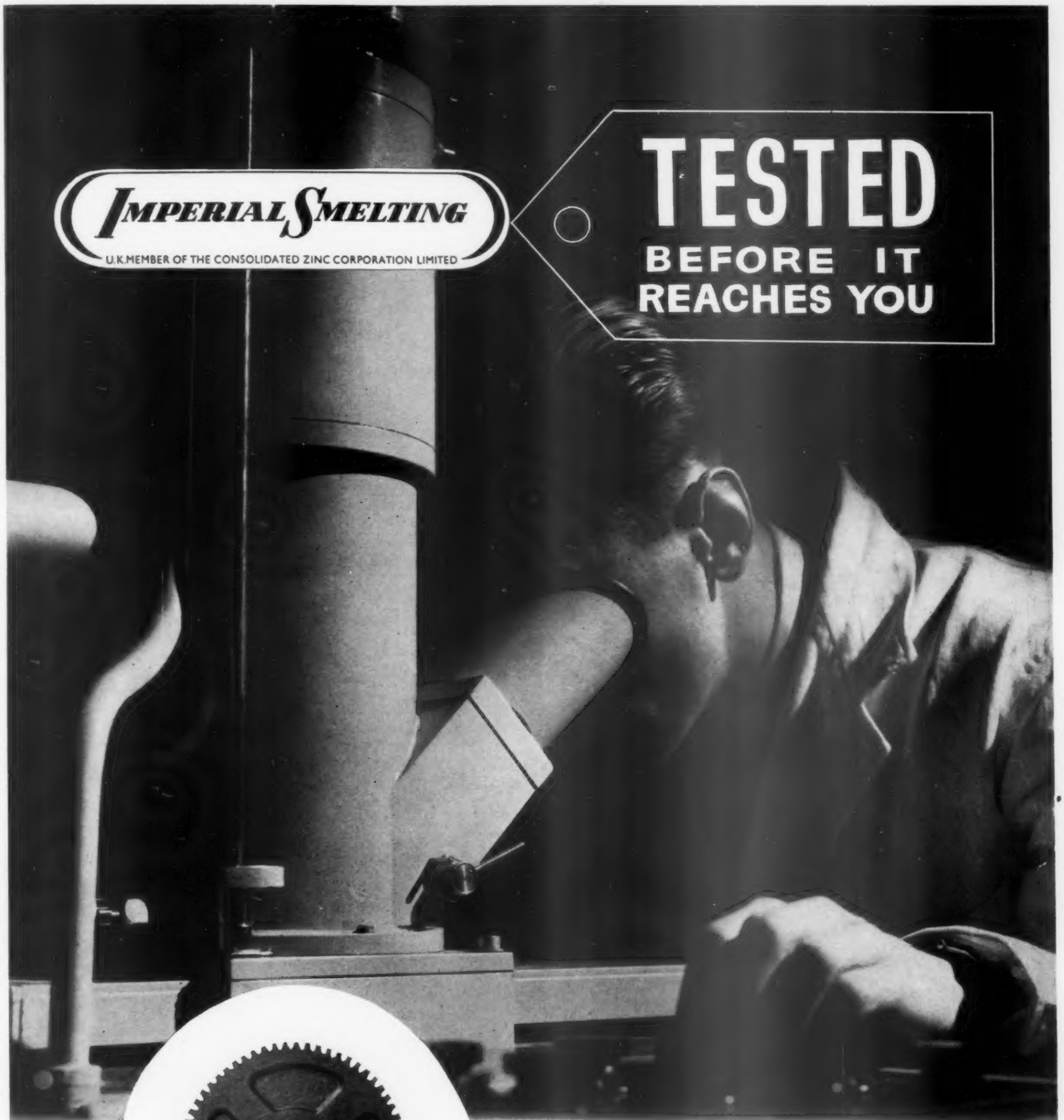

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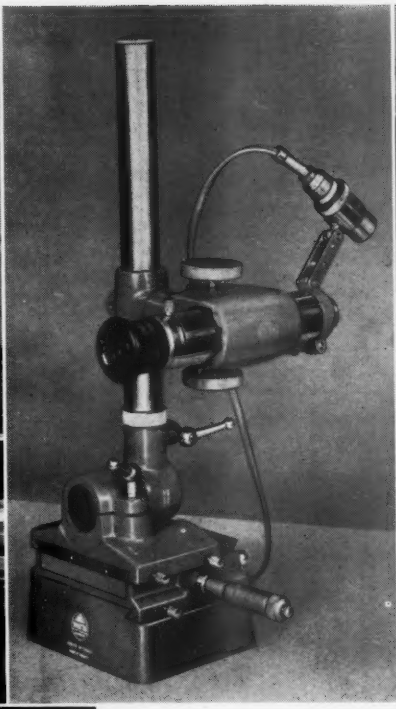

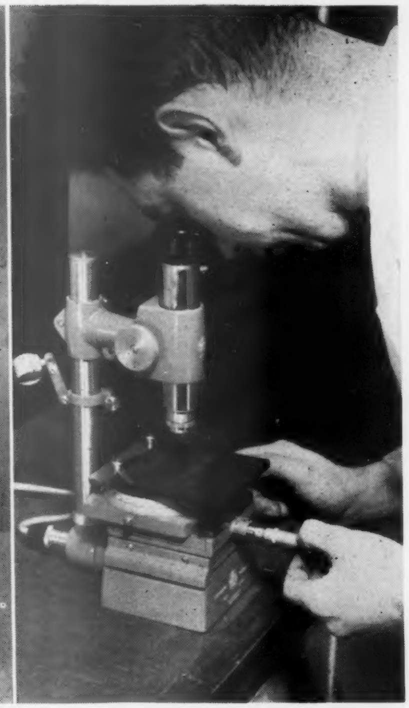

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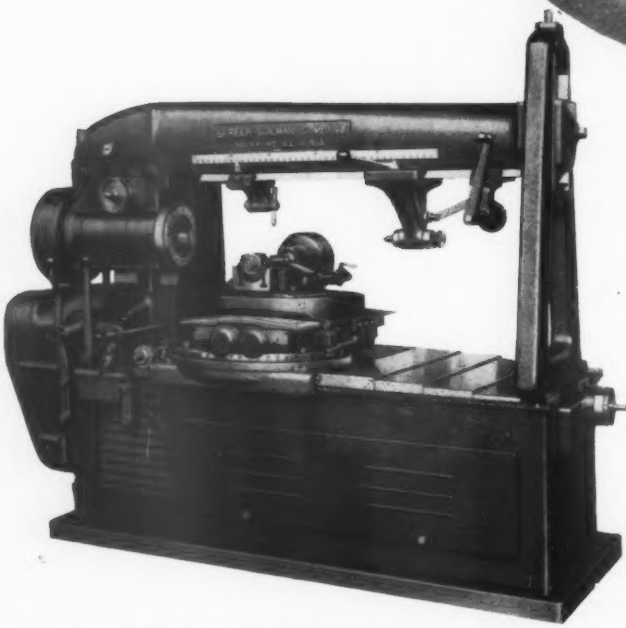

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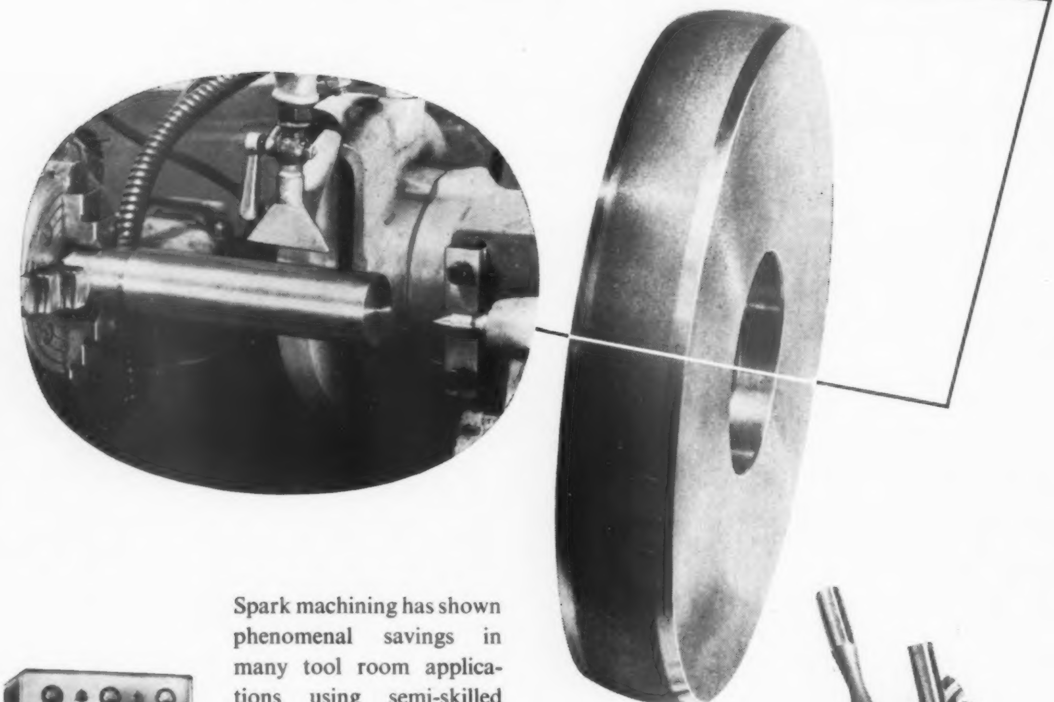

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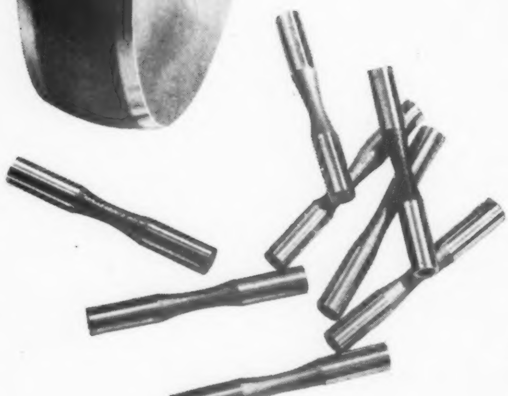

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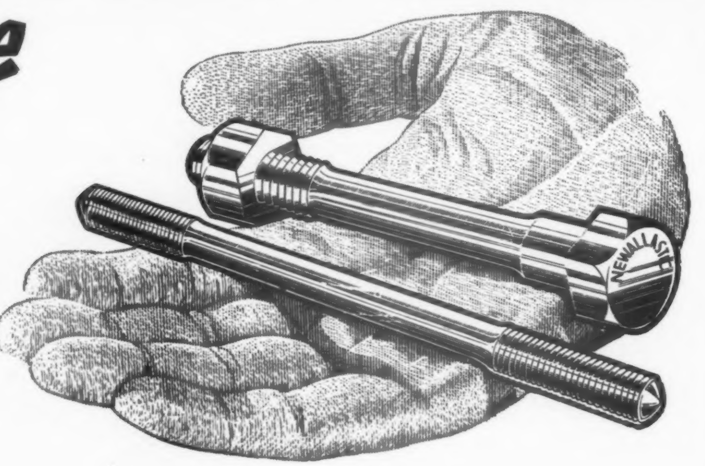

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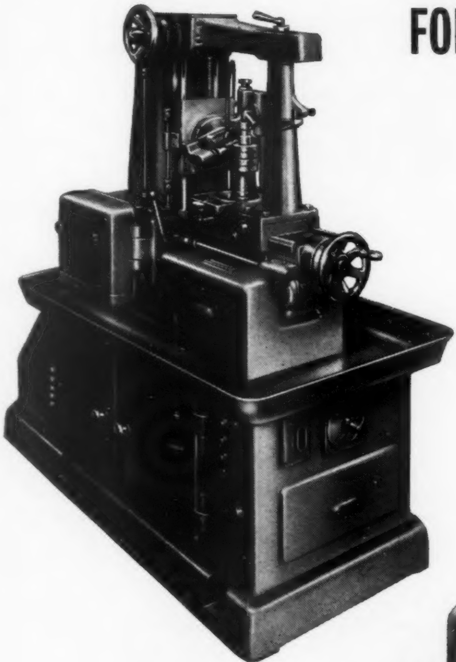

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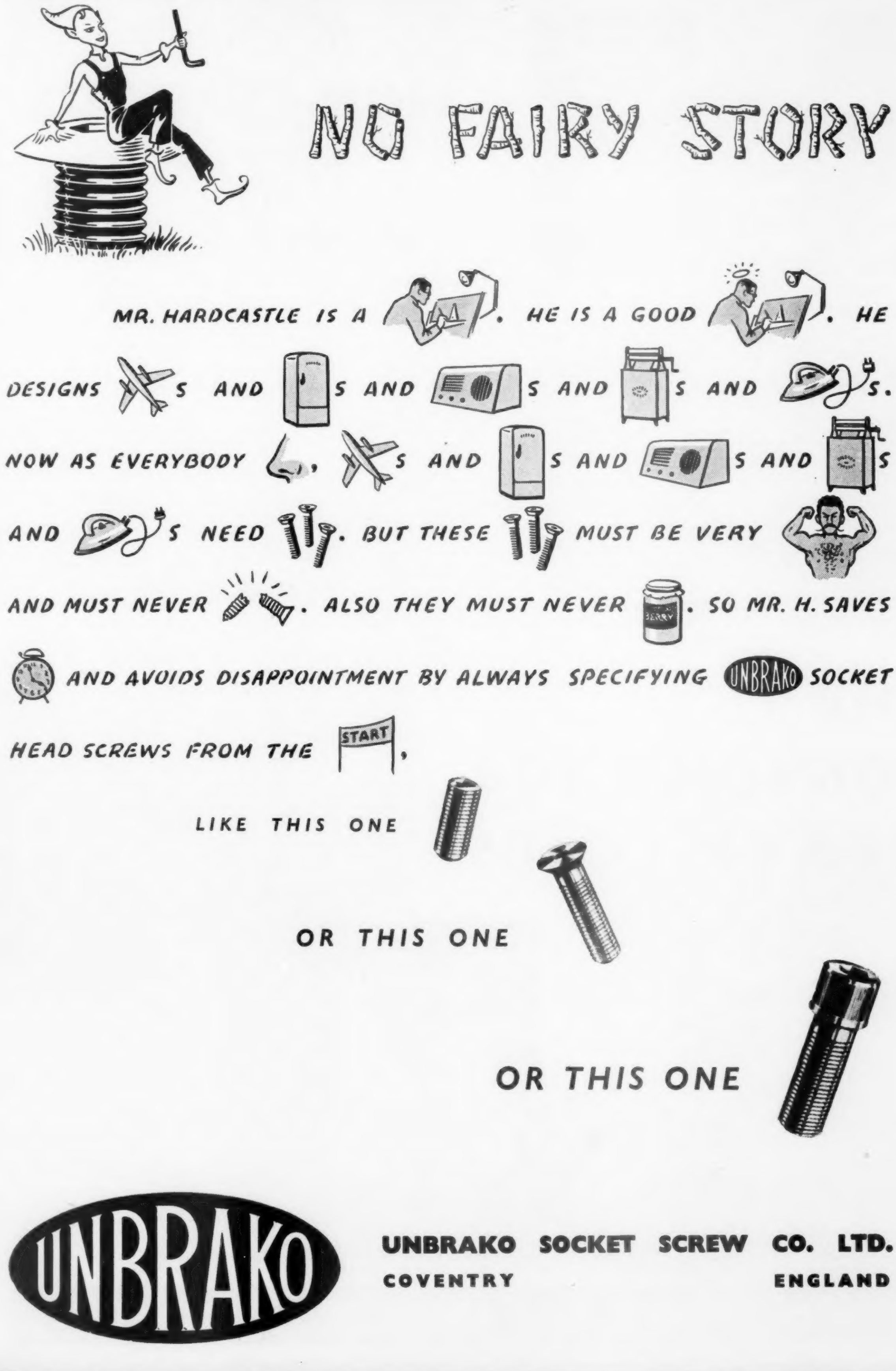
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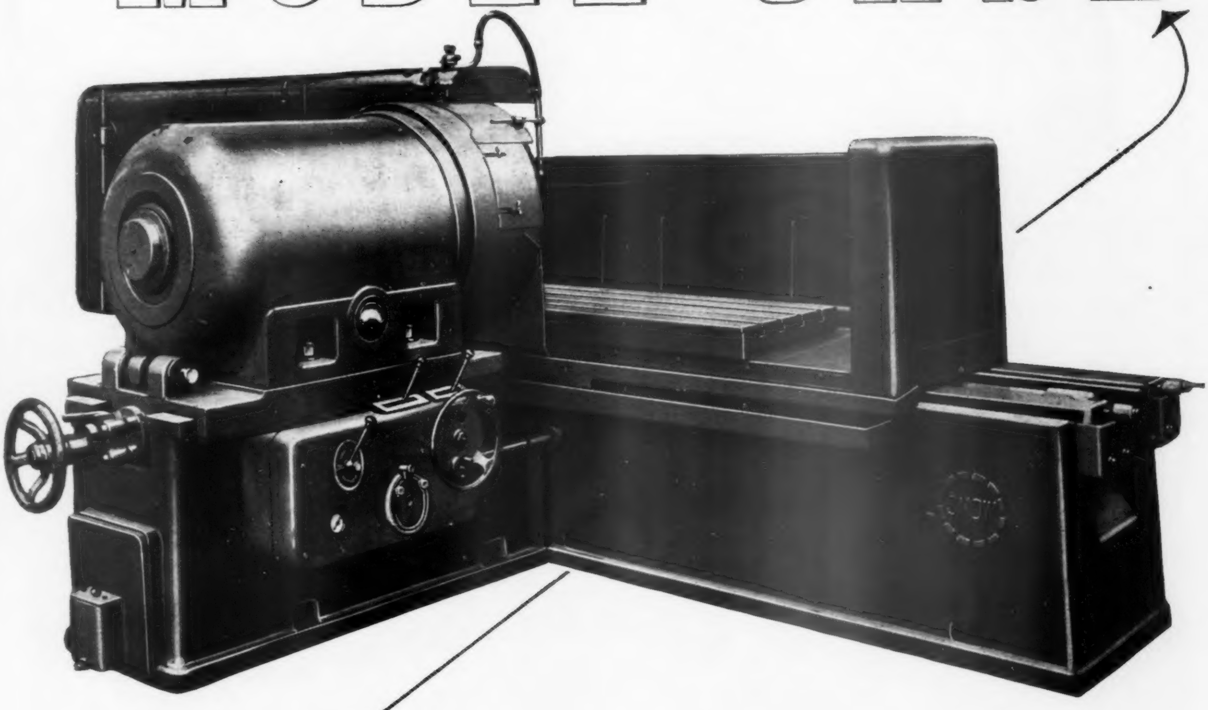

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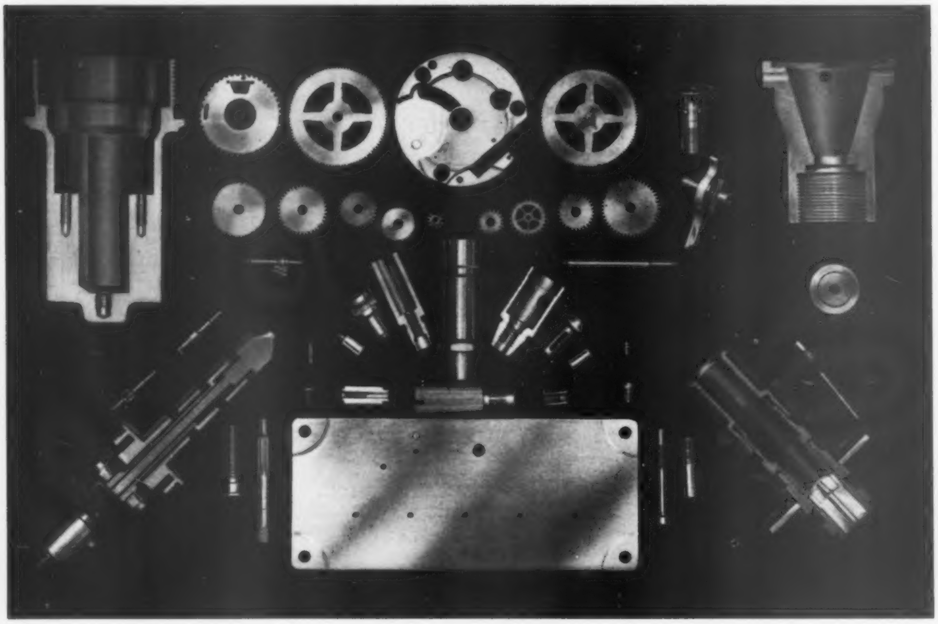

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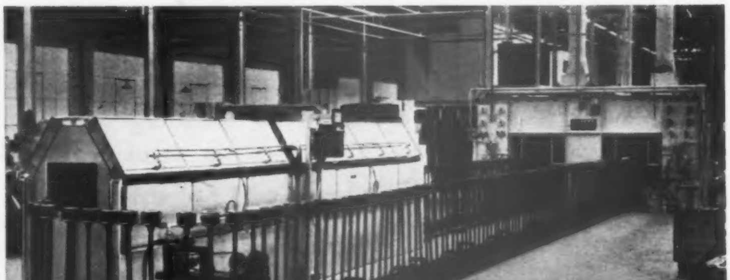

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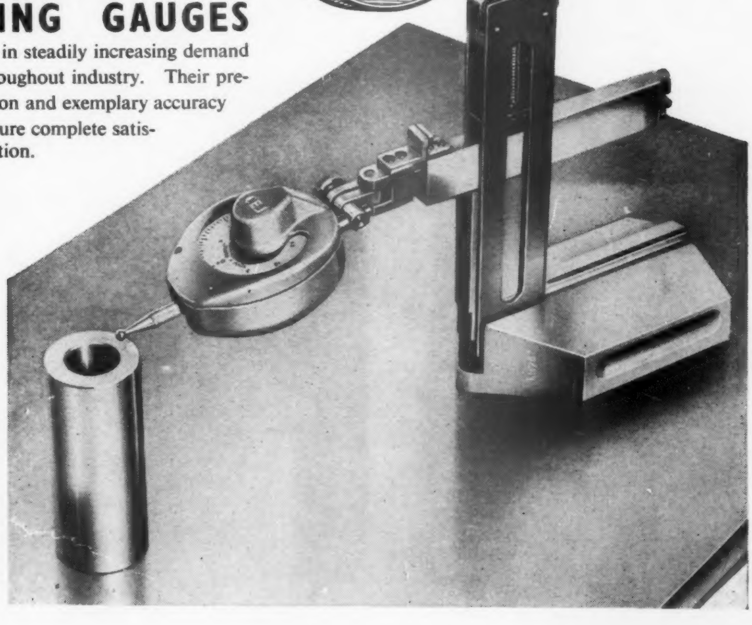
CEJ ROUND DIES

Adjustable or solid; obtainable in all standards.



CEJ Minikator

A micro-indicator especially designed for transferring dimensions and particularly suitable for indicating out-of-roundness or concentricity of machine spindles and for setting up components. Twisted strip amplification purely mechanical, without friction or slackness. Two measuring points supplied with every instrument. One providing a measurement range of .003″ with .00005″ dial graduations, the other providing a range of .006″ with .0001″ dial graduations. The illustration shows the Minikator being used in the CEJ Gauge Block holder and base.

C.E. JOHANSSON LTD.

A.I.D. & A.P.I. APPROVED

PRECISION TOOLS AND INSTRUMENTS

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INDEX TO ADVERTISEMENTS

All communications regarding advertisements should be addressed to the Advertising Managers, T. G. Scott & Son, Ltd. Crown House, 143-147, Regent Street, London, W.1. Phone: Regent 3891.
Printed by Maxwell, Love & Co. Ltd., White Lion Street, London, N.1.

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JOURNAL SUPPLEMENT

Vol. 33, No. 6
June, 1954

INSTITUTION OF PRODUCTION ENGINEERS, 10, CHESTERFIELD ST., LONDON, W.1

WANTED

Materials Handling Case Studies :

A. Bringing Materials to the Works.
B. Bringing Materials to the Work Station.
C. Handling at the Work Station.
D. Removal of the Job, Swarf and Scrap.

The Chairman of the Materials Handling Sub-Committee, Mr. T. W. Elkington, writes to members:

"Materials Handling is recognised as an ever-developing part of production engineering and the application of the right method for moving materials throughout the country and in the factories can effect substantial savings to manufacture in general.

"The Materials Handling Sub-Committee, of which I am Chairman, has recently been reconstituted to carry on the work of dealing with all aspects of this subject—administrative, technical and economic—and functions to stimulate interest and encourage by education and exchange of knowledge the wider use of modern handling methods.

"It is the opinion of this Sub-Committee and the Research Committee that medium and small firms could benefit by further knowledge of the subject, and it has been generally agreed that "Case Studies" provide the ideal medium for this purpose. It is felt that members could help in this matter and I ask all members to look around and forward to the Secretary details of successful handling set-ups.

"Case Studies should eventually be in the form of small "papers" with illustrations and facts about 'before and after' results. A number of these Case Studies would eventually form a useful Report, and in this way up-to-date information can be received and exchanged.

"Materials Handling covers a wide field—embracing simple lifting, transporting and gravity feeds to automatic movements, and new ideas are being continually developed. I would be grateful, therefore, if members would co-operate in this matter and hope that this request will receive a good response. The name of any firm need not be disclosed in any subsequent publication; it would be appreciated, therefore, if members would state their Company's decision in this respect. If you are able to help, please write to The Secretary, The Institution of Production Engineers, 10, Chesterfield Street, London, W.1."

PRODUCTION APPOINTMENTS

BULLETIN No. 45

This bulletin is circulated to all members of the Institution monthly as near as possible to the first of the month. Firms or organisations wishing to insert notices in the bulletin should communicate with the Secretary at 10, Chesterfield Street, London, W.1.

The last date for receiving material for insertion in the following month's bulletin is the 20th of each month.

The fee for insertion of particulars regarding each appointment is £3 3s. (up to 100 words), and over 100 words £5 5s. No charge is made to firms affiliated to the Institution, Technical Colleges, Universities and similar organisations.

Advertisers are advised that better response is likely if, in addition to essential qualifications, the following information is given :-
(*a*) Location of appointment; (*b*) Status in the organisation and scope of promotion; (*c*) Salary range and age range.

Advertisers are asked to advise the Institution when vacant appointments are filled. The Institution reserves the right to refuse or withdraw any announcement and also to make any alteration in the wording to ensure conformity with Institution standards.

Members interested in the following appointments should make application in accordance with the terms of notice. No correspondence can be undertaken by the Secretary other than the forwarding of replies to Box Nos.

Assistant to Works Manager. The Berkel Auto-Scale Co. Ltd., wishes to notify all applicants that the appointment of assistant to Works Manager has now been filled.

First-class Jig and Tool Designer required by Mechanical Engineering firm in Nottingham. State age, experience and salary required to Box No. 783, I.Prod.E., 10, Chesterfield Street, London, W.1.

Manufacturing or Methods Engineers and Product Development Engineers. Progress in manufacturing methods and techniques in connection with heavy rotating electrical machines and Mercury Arc Rectifiers have led to several interesting vacancies in The English Electric Co. Ltd., Stafford, for Manufacturing or Methods Engineers and Product Development Engineers. Applications are invited from engineers working in either of these capacities and from those who have a sound background of practical experience in a manufacturing industry, at least O.N.C. and a desire to enter either of these important branches of engineering. Please write quoting Ref. 1225A, to Dept. C.P.S., 336/7, Strand, W.C.2.

Jig and Tool Draughtsman needed for Excavator Division of Newton Chambers & Co. Aged 25-30 with experience of designing jigs and fixtures for machining and assembling medium sized components. The post is permanent and pensionable with excellent prospects for the selected draughtsman. Please reply giving details of age, experience and present salary to Personnel Officer, Newton Chambers & Co. Ltd., Thorncliffe, near Sheffield.

Designer Draughtsman required to take charge Section responsibilities for Refrigerator Cabinet and Systems Design under Chief Engineer. Salary by arrangement. Own staff are aware of vacancy. Write giving details of experience, salary required, etc., to Works Manager, Nash-Kelvinator Limited, Pym's Lane, Crewe.

Assistant to Works Manager. A man with experience in Machine Shops and Sheet Metal Working Shops between the age of 30 and 40 years required to act as Assistant to Works Manager. Experience must have been gained on repetition work of high quality and applicant must have up-to-date knowledge of Modern Machine Tools and their application. Preferably conversant with modern methods of cost as applied to production. Fully detailed applications should be addressed to Personnel Manager, Box No. 807, I.Prod.E., 10, Chesterfield Street, London, W.1.

Capable Jig, Tool and Machine Tool man wanted for senior position in Planning Office. State age, qualifications, experience in chronological order, salary required, etc. Progressive post. Pension scheme. Only applications from men with the right background will be entertained. Replies should be addressed to Works Manager, Box No. 823, I.Prod.E., 10, Chesterfield Street, London, W.1.

Methods and Work Study. A well known South Midlands Light Engineering Company is expanding its activities in relation to Methods and Work Study. Applications are invited from keen apprentice served engineers who consider they have a flair for this type of work. Minimum qualifications should include Ordinary National Certificate, an enquiring mind, the ability for original thought, coupled with common sense, and above all, enthusiasm for the job. If you are aged 25-35, ambitious, and possess the above qualifications, then reply giving full particulars of your experience and the salary required to Box No. 819, I.Prod.E., 10, Chesterfield Street, London, W.1.

Plant Draughtsmen required for engineering factory in Lancashire, over 21 years of age. Must hold Ordinary or Higher National Certificate. Experience on planning and plant lay out and with practical background of a works engineering department. Five-day week, canteen facilities, staff pension scheme. Apply to Box No. 824, I.Prod.E., 10, Chesterfield Street, London, W.1.

Experienced Work Study Man to establish work values for a light engineering factory; detailed knowledge of method study techniques is essential. Preference will be given to applicant who has had experience as head of a work study department. Good salary to right man. Box No. 825, I.Prod.E., 10, Chesterfield Street, London, W.1.

Works Manager required for medium/heavy engineering works in Manchester employing approximately 400 people in total. Good salary and excellent prospects. Box No. 826, I.Prod.E., 10, Chesterfield Street, London, W.1.

Senior Jig and Tool Draughtsman required to take charge of Drawing Office of a modern medium sized engineering company in the Manchester area. Post is pensionable. Applicants must be conversant with advanced methods of jig and tool design. Please apply giving age, education and experience, giving details of any specialised training or experience. Box No. 827, I.Prod.E., 10, Chesterfield Street, London, W.1.

Draughtsmen, Senior Jig and Tool, must have served apprenticeship and attained H.N.C. Experience required must be related to chucking automatics, also mill, drills broaching and grinding machines. Pension scheme, excellent canteen. Successful candidates will be re-housed at Hemel Hempstead. Apply in writing only giving full details of experience, salary required, etc., to Labour Manager, Alford & Alder (Engineers) Ltd., Maylands Avenue, Hemel Hempstead.

Production Engineers. A Sheffield Company has vacancies for two Production Engineers—University Graduates or equivalent standard with three years' practical industrial experience. Age approximately 27 years. Applications with full particulars to British Acheson Electrodes Limited, Grange Mill Lane, Wincobank, Sheffield 9.

Planning Engineer (Junior) required, age group 22-25, with experience on medium size machined components. Applicant must have obtained either O.N.C. or H.N.C. Well established company in Hemel Hempstead, housing available to selected candidate. Write full details of experience in chronological order, and remuneration required, to Box No. 828, I.Prod.E., 10, Chesterfield Street, London, W.1.

Superintendent of Tools required by well-known Birmingham manufacturer of domestic appliances. The successful applicant will control the design and manufacture of large and varied tooling projects, ranging from heavy presses to precision small tools. The Company is re-organising its Tool Room on most modern lines and the Superintendent must be willing to travel and study foreign toolmaking methods. A knowledge of French and German an advantage. The position is permanent and carries a generous salary for the right type of man. Applications, which will be treated with full confidence, are invited only from men of the highest qualifications and experience, and should be addressed to Box No. 829, I.Prod.E., 10, Chesterfield Street, London, W.1.

Qualified Work Study Engineer required by Oil Engine Division, Rolls-Royce Limited. The applicant must be capable of the detail analysis of all the direct and indirect functions of manufacture and the subsequent preparing and introduction of labour and cost reducing methods. Age not over 30. Applications should contain full details of qualifications, experience and salary required, and be addressed to the Labour Manager (0), Rolls-Royce Limited, Derby.

Estimator/Tooling Engineer. Experienced Estimator required for Tool Engineering Department of large engineering concern. Applicants must be fully conversant with modern tooling methods, as applied to multi or single spindle automatics, both bar and chucking machines and possess sound practical training, together with some drawing office experience. Please state in writing full particulars of age, qualifications, experience and remuneration required to Personnel Manager, B.S.A. Tools Ltd., Kitts Green, Birmingham, 33.

Tooling Designers required for tool engineering department of large Midland engineering concern. Applicants must be fully conversant with modern tooling methods as applied to multi or single spindle automatics or/and capstan lathes, both bar and chucking machines and possess sound practical training. Please state in writing full particulars of age, qualifications, experience, and remuneration required to Personnel Manager, B.S.A. Tools Limited, Kitts Green, Birmingham, 33.

Tool Room Superintendent. A vacancy exists with a well known Birmingham Engineering Company for an energetic and experienced man to take charge of a department manufacturing mainly heavy press tools, with some light tooling. The successful applicant must have had a wide experience of the production of such tools by modern methods. This is a permanent and senior appointment, and the Company is prepared to pay a four figure salary for the right type of man. Applications, to be dealt with confidentially, should be addressed to Box No. 830, I.Prod.E., 10, Chesterfield Street, London, W.1.

Technically Qualified Man. An old established and progressive engineering firm employing 300 workpeople in the West Riding of Yorkshire is seeking a technically qualified man of experience and initiative to set up and take charge of a new Production Engineering Department, including Work Study, Operation Planning and Ratefixing. Applicants should be between 30 and 40 years of age and possess sound knowledge of fabricated platework, general machine shop and foundry practice. Experience of work study would be an advantage but training would be given to successful applicant if necessary. Write stating age, experience and salary required to: Urwick Orr & Partners Limited, 28, East Parade, Leeds 1, quoting reference number BCH/1110.

Methods Engineer required with good practical background experience in up to date techniques of assembly, fabricating, welding and finishing operations. Duties will include the planning of processes preliminary to the production of new appliances and the investigations of existing methods and costs. Education standard to H.N.C. desirable. The appointment is a permanent and pensionable one, with a generous salary for an energetic and resourceful type of man, age 25-40. Applications, in strict confidence, to Personnel Manager, Parkinson Stove Co. Ltd., Iron Lane, Stechford, Birmingham, 33.

Production Engineer required, age 30-35, to assist Works Manager. Essential qualifications: Good general apprenticeship and drawing office experience; knowledge of modern machine shop methods; Jig and Fixtures design; Planning and Ratefixing methods in batch production. Foundry experience an advantage. Candidate must have personality and drive, and be prepared to handle labour. The post is available in a large engineering Works in the Huddersfield area. A pension scheme is in operation. Applicants should also give full details of general education, training, subsequent experience, and salary expected. Box No. 831, I.Prod.E., 10, Chesterfield Street, London, W.1.

Development Engineer required by engineering concern in the North of England specialising in high quality gearing and transmission equipment. Candidates, between 35 and 42 years of age, should have substantial technical background, an engineering degree preferred. They should be conversant with modern engineering techniques and be able to take charge of development and to exercise full leadership in that field. A thorough knowledge of metallurgy is an advantage. Applicants should be lively minded and have significant experience with industry and its commercial aspects. Remuneration—£2,000/2,500 per annum, with excellent prospects. Position fully pensionable. Applications which will be treated in strictest confidence, should be addressed to Harold Whitehead & Partners Ltd., Management Consultants, 31, Palace Street, London, S.W.1.

Time Study Engineer. A modern and expanding Company in South Wales requires a fully-experienced Method and Time Study Engineer. Essential qualifications include a sound education, a wide experience in all aspects of Work Study, preferably in several industries, personality suitable for this type of work. A contributory pension scheme is in operation. Send details of past experience and employers, education, qualifications and salary required to Box No. 832, I.Prod.E., 10, Chesterfield Street, London, W.1.

Production Engineer with flair for administration required to act as Manager of Division of Midlands Engineering concern. Division does substantial business in finished machined and assembled components, with turnover of several million pounds per annum. Qualities required are sound engineering and technical knowledge and experience coupled with organisational ability, energy and initiative. Will be responsible only to General Works Manager and Directors. Only applicants with top level experience and qualifications will be considered. Salary not less than £1,500 per annum. Box No. 833, I.Prod.E., 10, Chesterfield Street, London, W.1.

Experienced Engineer. A post which offers an interesting and progressive career for an experienced engineer to take charge of work study, occurs in an established and modern factory. He must be experienced in modern work study techniques and be able to contribute to production methods. He should be energetic and have a strong sense of purpose with high integrity. Write giving fullest details of experience, age and salary required to the Welfare Officer, The Shannon Limited, New Malden, Surrey.

Senior and Junior Jig and Tool Draughtsmen. Rotax Limited, Aircraft Electrical Engineers, require Senior and Junior Jig and Tool Draughtsmen to deal with the tooling of electrical and mechanical aircraft equipment. The positions are superannuated and offer considerable scope to men with adequate experience. Suitable applicants will have the opportunity of renting a modern house in the area of the New Town, and preference will be given to candidates who are on an approved housing list in the Greater London area. Applications should be made in writing to the Personnel Manager, Rotax Limited, Maylands Avenue, Hemel Hempstead.

Methods Engineer required, age 25-35, with a sound knowledge of tooling and methods applied to capstan work, milling, drilling and assembly in light/medium quantity production factory. Duties will include responsibility for operation lay-outs, estimating costs on new jobs, etc. The position is permanent and pensionable, with scope for an energetic man with up-to-date and progressive ideas. Apply, in confidence, to Personnel Manager, Monitor Engineering and Oil Appliances Ltd., Iron Lane, Stechford, Birmingham, 33.

Production Engineers with versatile experience in Methods Planning, Press Tools, Jigs and Fixtures and Gauge design, also design of special machines. Confident and competent to control assistant executives and staff. Ability to negotiate with customers at top level. The positions are permanent, and salary commensurate with responsibilities. Applicants must be between age 30-35 and possess previous experience in similar position. Qualified A.M.I.Mech.E. and/or A.M.I.Prod.E. Successful applicant will receive Directorship after first year's service. Locations, Midlands and West of England. Applicants must state details of career and salaries to date. Box No. 834, I.Prod.E., 10, Chesterfield Street, London, W.1.

Production Planning Engineer. An excellent opening, with housing assistance if required, occurs with progressive company for Production Planning Engineer with drive and initiative. Products covering wide range of machining, fabrication, painting and assembly. Must be fully experienced all branches production engineering including modern factory methods, planning, jig and tool design, progress. Knowledge of materials handling an advantage. H.N.C. preferred. Company situated in pleasant country district one hour West of London. Canteen facilities. Please write giving details of age, past experience, married/single, present salary, to the Personnel Officer, Lansing Bagnall Ltd., Kingsclere Road, Basingstoke.

Qualified Designers and Draughtsmen. The British Northrop Loom Company Ltd., which operates a well equipped plant employing nearly 3,000 people in the manufacture of automatic weaving machinery, is extending its research and design division and has vacancies for qualified designers as well as draughtsmen. Ages 30-45. Experience of textile machinery not essential provided applicants are adaptable and possess proved designing ability. Practical drawing-board experience and a good training in medium sized engineering essential. The positions are intended to be progressive and permanent and offer good prospects to the right men. Attractive salary and generous pension scheme. Apply to the Secretary at the registered office, Blackburn, Lancs.

Works Manager, wanted for engineering works on East Coast of Scotland. The works are old established and comprise Iron Foundry, Machine Shops, along with plate and light structural shops, for producing medium to heavy engineering work. Applicants must be thoroughly experienced and have held executive production posts at a managerial level. Age 30 to 50. Apply giving full particulars to Box No. 835, I.Prod.E., 10, Chesterfield Street, London, W.1.

A Production Executive is required for a light engineering factory in Yorkshire, employing about 1,000 operators. The successful applicant will be required to take full charge, under the General Manager, of all aspects of manufacture. These will include the machining and assembly shops together with certain specialised processes, production control planning and work study, etc. Essential qualifications are a sound mechanical engineering background with experience in precision engineering, proved ability to control work people, and a good knowledge of quantity production. Age should be between 32 and 45. This is a senior position for which a good salary will be offered and there are prospects of further advancement. In the first place send brief particulars with especial reference to the essential qualifications mentioned earlier, Box No. 836, I.Prod.E., 10, Chesterfield Street, London, W.1.

Products Engineer required by well-known Slough engineering company. Applicants must have first rate general engineering knowledge and experience, capable of commercial liaison on standard products. Apply in confidence giving details of career and salary required to General Manager, Box No. 837, I.Prod.E., 10, Chesterfield Street, London, W.1.

Estimator for Works Engineer's department of cable factory to cover all operations, including manufacture, assembly and installation of new work, also dismantling, transfer and re-installation of existing plant. Essential qualifications:—Eng. apprenticeship with at least five years' subsequent engineering experience, including drawing office. Good pay and prospects for right man. Apply, quoting E/1/54, to Staff Officer, B.I.C.C. Ltd., Belvedere, Kent.

Graduate Mechanical Engineer, aged 25-35 years, having a first or second class honours degree is required by a National Organisation for a permanent appointment on work concerned with research and development of production processes. The work is varied and interesting and may include liaison with engineering firms throughout the country. Excellent prospects for man with initiative and personality. The position is superannuated and carries a good commencing salary. Send full details in confidence to Box No. 838, I.Prod.E., 10, Chesterfield Street, London, W.1.

Manager required for control of specialised engineering work at modern factory in the North West. Previous experience required in operating planning, tool design, progressing and other functions of factory administration. Familiarity with group and individual piecework schemes, for large and small batch production. Applications should state age, previous engineering experience and details of technical education, together with an indication of salary required, to Box No. 839, I.Prod.E., 10, Chesterfield Street, London, W.1.

Assistant to Chief Engineer required by a light engineering firm in Sheffield. Candidates should be qualified engineers, about 26 to 30 years, preferably with a degree. The post will carry a good commencing salary with excellent future prospects for a young man of energy and initiative. Box No. 840, I.Prod.E., 10, Chesterfield Street, London, W.1.

Experienced Designer and Engineer required to develop and control well equipped light sheet metal plant for manufacturers of wheelbarrows, lockers, storage binning, etc., and sheet metal work generally. (20/30 operatives.) Excellent opportunity for energetic man with initiative. Expanding organisation; good remuneration. Leicester area. Box No. 841, I.Prod.E., 10, Chesterfield Street, London, W.1.

Experienced Mechanical Engineer with administrative and organising ability required by East Midlands concern to take supervising charge of its light engineering section. The applicant should have a sound practical and workshop training in addition to a good theoretical knowledge. While the main duties are concerned with mechanical developments and production problems, the product has an electrical application, hence a broad electrical knowledge is decidedly advantageous. The selected candidate will be responsible for the operating of his own section and should have initiative, drive and imagination. Apply stating age, qualifications, experience and salary required to Box No. 842, I.Prod.E., 10, Chesterfield Street, London, W.1.

Engineering Staff. The Bristol Aeroplane Company Limited Aircraft Division (Western Factory), Weston-Super-Mare, are expanding their organisation and require the following personnel for interesting work on Aircraft, Helicopter, and Rocket Motor Tube projects: **Planning Engineers and Ratefixers** for machines, fitting and assembly shops, **Jig and Tool Draughtsmen, Production Control Staff, Technical Clerks.** Staff Pension and Life Assurance scheme. Apply to the Personnel Manager, Dept. 64, giving details of age, experience and qualifications.

Production Engineers. A large group of engineering companies with overseas interests, having its headquarters in the Midlands, invites applications from qualified production engineers now holding executive or management consultant status. Applicants, who should be approximately 28 to 35 years of age, must have a good knowledge of industry. Although the approximate range of remuneration is £1,500/£2,500 per annum, the actual salaries offered will correspond to the ability and experience of the successful candidates. The posts now open can lead to senior executive positions with the company. An excellent pension scheme is in operation. Candidates, whose applications will be treated in strict confidence, should supply full details of present salary, age, industrial background, technical qualifications and education by writing to Box 843, I.Prod.E., 10, Chesterfield Street, London, W.1.

Draughtsmen. G. A. Harvey & Co. (London) Ltd., Woolwich Road, Charlton, S.E.7, have vacancies for the following:—Plant Draughtsmen with experience of Mechanical and/or Electrical Maintenance and General Development work on special purpose machinery and processes. Draughtsmen for Sheet Metal Work, familiar with Sheet Metal Development, Heating, Ducting and Ventilation. Regular employment, Superannuation Scheme, Canteen, Sports and Social Club. Apply in writing, stating age, experience, qualifications and salary required to Labour Department.

Qualified Engineer. A few special vacancies exist at a large group of well known Aircraft Constructors in the South of England for qualified men up to the age of 35 with engineering experience to commence with Assistant Works Manager status and salary. An exceptional opportunity for energetic, capable and ambitious men with minimum qualification of Higher National Certificate and some Works' experience. Reply in writing to Box No. 844, I.Prod.E., 10, Chesterfield Street, London, W.1.

Junior Development Engineer (age 23-28) wanted by Engineering firm in S.E. London. Interesting and varied work in Mechanical and General Engineering. Ordinary National Certificate or Inter. B.Sc. desirable. Apply stating age, experience and salary required to Labour Dept., G. A. Harvey & Co. (London) Ltd., Woolwich Road, Charlton, S.E.7.

General Manager required for small engineering works specialising in machining of stainless steel, in the London area. Small milling and turning mainly, and about thirty employees. This unit is one of a group and the successful applicant who must be practical, would be directly responsible to the Board for its detailed operation including buying and sales. A four figured salary will be dependent on qualifications and achievement. This post offers great scope to a suitably qualified man with the necessary drive and ambition. Applications to N. A. Cullin, Management Consultants, 16, New Street, Leicester.

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Time and Motion Study Engineer for a small factory in London area. Sound training in engineering and time study practice. If possible, applicants should have experience of precision engineering and electrical assembly work. Full particulars to Box No. 845, I.Prod.E., 10, Chesterfield Street, London, W.1.

EDUCATIONAL APPOINTMENTS

Wolverhampton Technical High School

(1) **Deputy Head.** (2) **Head of Engineering Department.** Applications invited for the following posts in the above mixed secondary technical school. Roll 700 approx. (aged 11-17), including 40 in VI form.

(1) **Deputy Head**—Man, highly qualified graduate in applied or pure science, or arts. Burnham scale with special responsibility allowance of not less than £150 per annum.

(2) **Head of Engineering Department**—Graduate in engineering. Burnham scale with special responsibility allowance of not less than £100 per annum. For each post suitable experience, not necessarily in a secondary technical school, is essential. Candidates for (2) should state whether they wish to be considered also for (1). Forms of application and further particulars from Director of Education, Education Office, North Street, Wolverhampton; completed applications should be returned within fourteen days of the date of this advertisement.

Coventry Technical College, Coventry

Lecturer, Assistant Grade B, Assistants Grade A (three vacancies). Applications invited for following full-time teaching posts in Mechanical Engineering Department, commencing September next. Candidates should be Graduates or hold good technical qualifications and have had good industrial experience; previous teaching experience advantageous:—

Lecturer—Graduate in Engineering able to offer one or more subjects to final B.Sc.Engineering. **Assistant Grade B**—with special knowledge of Production Engineering.

Assistants Grade A (three vacancies)—one post allocated primarily for Patternmaking and Foundry work; applications for other posts from those experienced in some branch of Mechanical, Automobile, Aeronautical or Production Engineering. Salary—Burnham Technical Scale. (Lecturer: £940—£1,040; Grade B: £490—£765; Grade A: £415—£670.) Application forms and further particulars from Director of Education, Council House, Coventry, returnable without delay.

Hackney Technical College

Assistant Grade B.

Assistant Grade B to teach mechanical engineering subjects to Final C and G. Machine Shop Engineering standard and engineering drawing to S.2. O.N.C. Ability to assist in theoretical and practical classes for Motor Vehicle Service. Mechanics National Craftsmen Certificate an advantage. Burnham F.E. Salary scale £490 x £25—£765 plus London allowance £36 or £48. Application forms from Secretary at College, Dalston Lane, E.8, for return by 19th June. (524.)

College of Further Education, Redditch

Assistant Grade A. Applications are invited from suitably qualified persons for an Assistant, Grade A, to teach English Language for Joint Section "A" Examination, and Mathematics, and/or Engineering Science, to part-time day students in Engineering Courses to S1 level. Previous teaching experience desirable. Application forms may be obtained from the Director of Education (S/J), County Education Office, Castle Street, Worcester, on receipt of stamped addressed foolscap envelope.

Rutherford College of Technology

Assistant Grade A. Wanted for September, Assistant, Grade A, to teach Engineering Drawing and Science to National Certificate and Diploma students. Good industrial experience and qualification of at least Higher National Certificate standard required. Salary at present £415 x £18—£670; allowance on scale for industrial experience. Further details and forms of application obtainable from Director of Education, Northumberland Road, Newcastle-upon-Tyne 1, to whom completed forms should be returned within fourteen days.

Brooklands County Technical College, Heath Road, Weybridge

Lecturer and Assistants Grade "A" or "B" in Production Engineering. Applications are invited for the following posts:—(a) Lecturer and (b) Assistant Grade "A" or "B" in Production Engineering for O.N.C. courses in Production Engineering and City and Guilds courses in allied subjects. Applicants should possess sound technological qualifications and have had suitable industrial and teaching experience. Preference will be given to those with knowledge of Machine Tools, Jigs and Fixtures, Metrology, Heat Treatment and Welding Practice. Salary:—Burnham Technical Scales—Lecturer: £940 x £25—£1,040 per annum. Grade "B" £490 x £25—£765 per annum. Grade "A" £415 x £18—£670 per annum. Assistant Grade "A" or "B" to teach Sheet Metal Work to City and Guilds students. Ability to teach Motor Body Work and Welding an advantage. Salary Scales as above. Application forms and further particulars obtainable from the Principal at the College. Completed forms should be returned within fourteen days from the appearance of this advertisement.

Technical College, Dartford

Turner or Workshop Mechanic, required, skilled on all types of lathes and preferably with some experience on other machine tools for a position of responsibility in the workshop of the Technical College, Lowfield Street, Dartford. Ability to assist with instruction of apprentices an advantage. Salary (38-hour week) within Scales—£395—£460 and £440—£520. Apply to Principal.